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## **Appendix 3-1**

**Evaluation of dissolved and colloidal metal  
concentrations in streamwater, French Gulch, Colorado**

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## **INTRODUCTION**

The role of colloids in the geochemistry of metals in natural waters is becoming more apparent as sampling methods and analytical capability become more refined (Buffle and Leppard, 1995a; 1995b; Stumm and Morgan, 1996). To understand the role of colloids in processes affecting contaminants, there must be adequate methods for their characterization. Colloids are solids with effective diameters in the size range from about  $10^{-9}$  to  $10^{-6}$  meters. Such small particles do not settle from the aqueous phase; their small size allows the Brownian motion of water molecules to keep them suspended (van Olphen, 1977). The small size results in extensive surface area that strongly influences the partitioning of toxic metals through sorption and coprecipitation (Jenne, 1977; Morel and Gschwend, 1987; and Stumm and Morgan, 1996).

Standard methods of filtration do not separate colloids from water. Jones and others (1974) recognized the inadequacy of filtration with 0.45-micrometer ( $\mu\text{m}$ ) membranes to exclude solids from samples for metal analysis of surface waters. They observed that very fine clay particles passed through 0.45- $\mu\text{m}$  membrane filters and affected the analysis of iron (Fe), aluminum (Al), and zinc (Zn). Recently, the role of colloids in regulating occurrence and transport of contaminants in ground water also has been studied (Roy and Dzombak, 1997).

When acid mine drainage enters streams with near neutral pH, Fe-rich colloidal material commonly forms in the water column (Kimball and others, 1994). This process makes the role of colloids in studying acid mine drainage particularly important. The initial precipitation of Fe hydroxides generally creates particles less than 1 nanometer (nm), or 0.001  $\mu\text{m}$  in diameter (Ranville and others, 1989; Grundl and Delwiche, 1993). The extremely small particles rapidly aggregate to form a continuous size range of particles from 1 nm to greater than 1  $\mu\text{m}$  (Buffle and Leppard, 1995a). Together, precipitation and aggregation result in a continuous range of particle sizes, complicating the task of filtration to obtain an operationally defined dissolved metal concentration can be complicated. Aggregation can cause the colloidal material to settle from streams where the Fe hydroxides are responsible for the ochre color

downstream from many mine sites (Bigham and others, 1990). Although many solutes do not form colloidal particles and 0.45- $\mu\text{m}$  filtration is adequate to define a dissolved concentration, there is nothing natural about distinguishing “dissolved” metal concentrations as the filtrate that passes through a 0.45- $\mu\text{m}$  filter. Such filtration only provides an operational definition for legal purposes. Some studies have used “ultrafiltration” using membranes with pore-sizes as small as 10 kiloDaltons (kDa) to separate this range of particle sizes from water (Moran and Moore, 1989; Kimball and others, 1994).

## PURPOSE AND SCOPE

The purpose of this report is to present results of filtration on samples from French Gulch, Colorado and to evaluate those results with a two factor analysis of variance design (fig. 1). In mine drainage that is not Fe-rich, metals can still be associated with colloidal-size particles that are often organic or biological debris, or metal-oxide precipitates other than Fe. Colloids often affect the cycles of toxic metals like cadmium (Cd), copper (Cu), lead (Pb), and Zn. These metals can sorb to the Fe hydroxides and become part of the biofilm coating the cobbles on streambeds as colloids are trapped and as aggregated colloids settle. This may represent an entry of the metals into the food chain as the biofilm is consumed by grazing benthic invertebrates. This can happen far downstream from where the visible Fe staining occurs. These examples will indicate the significance of colloids with respect to regulatory practices, process studies, and the evaluation of toxicity.



## **METHODS**

### **DISSOLVED METAL CONCENTRATIONS**

Dissolved metal concentrations must be operationally defined. Because of the formation of Fe- hydroxide particles ranging from less than 1 nm to greater than 1  $\mu\text{m}$  in streams affected by mine drainage, 0.45  $\mu\text{m}$  is neither an effective nor a natural break for the distinction of dissolved and particulate concentrations in these streams (Kimball and others, 1994). Standard U.S. Geological Survey procedure involves filtration with an in-line capsule filter of 0.45  $\mu\text{m}$  pore size (Horowitz and others, 1994). For this study, the operational 0.45- $\mu\text{m}$  definition of the dissolved fraction for this study was compared to tangential-flow ultrafiltration through a membrane with an effective pore size less than 0.001  $\mu\text{m}$  (Hernandez and Stallard, 1988; Kimball and others, 1994). Some water samples also were filtered through 0.1- $\mu\text{m}$  membranes. Table 2 summarizes the kinds of samples collected for the study. An unfiltered sample also was obtained for the determination of total recoverable metals.

The water remaining in the churn was filtered using tangential-flow filtration with either a Millipore Minitan or Pelican apparatus<sup>1</sup>. In theory, tangential-flow filtration keeps solid material suspended as water flows across the filter membrane, rather than forcing solids onto the filter. Osmotic pressure draws water through the membrane producing a filtrate that is free of the particulate solids greater than a size determined by the membrane pore size. Different pore sizes can be substituted into the same apparatus without changing any of the other conditions, allowing for a good test of variations due to pore size. This avoids filtration artifacts suggested by Horowitz and others, 1992. In practice, however, Fe-colloids accumulate on the filter membranes. Filtration with a 10kDa membrane caused no observable changes in

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<sup>1</sup> The use of trade names is for identification only and does not imply endorsement by the U.S. Geological Survey.

Fe concentration over time, suggesting that the initial pore size was sufficient to exclude colloids that would have passed through the larger pore-sized membranes. With 100 and 30 kDa membranes, however, the accumulation of colloidal material had observable effects. Concentrations of Fe in the filtrate progressively decreased to a constant value during filtration with these two membrane sizes. Others have found that the 10 kDa membrane is effective in distinguishing dissolved from colloidal metal concentrations (Moran and Moore, 1988; Witters and others, 1996).

Table 1. —Summary of samples collected for comparison of filtration effects.

Sample	Purpose
Unfiltered water	Total metal concentration, used to determine colloidal concentrations either directly or indirectly.
0.45- $\mu$ m filtrate	Legal definition of dissolved constituents (Horowitz and others, 1996)
0.1- $\mu$ m filtrate	Suggested as a better measure of dissolved concentrations for metals in surface water samples (Jones and others, 1974).
10,000-Dalton filtrate	An ultrafiltrate that limits particulate material to that less than about 0.00029 $\mu$ m (Hernandez and Stallard, 1987). This has been shown to be a better measure of "dissolved" metal concentrations in surface waters than the larger pore-size membranes (Kimball and others, 1995).

## COLLOIDAL METAL CONCENTRATIONS

Colloidal metal concentrations were determined by an indirect method. Subtracting the ultrafiltrate concentration from the total recoverable concentration is a representation of the colloidal metal concentration. If the two concentrations must be significantly different to results in a meaningful concentration. Generally, this indirect method works well for concentrations of Fe, Mn, and Zn. Both ultrafiltrate and total recoverable concentrations of cadmium (Cd), copper (Cu), nickel (Ni), and lead (Pb) often are too low to be used for calculation colloidal metal concentrations.

## STATISTICAL ANALYSIS

Filtration was considered a “treatment” in an analysis of variance design. The analysis of variance design included the three filtrate concentrations, but not the unfiltered concentration. Sampling sites were random factors, and a particular site was either upstream or downstream from the mine. With these factors, the variability of the metal concentrations can be evaluated by hierarchical design (Table. 1). In addition to following this design, one “site” was a field blank sample, or a sample of reagent grade water that was processed just like all the other samples to check for contamination, but was not included in the analysis of variance to test for differences among sites. This design will test the hypothesis listed in Table 1.

In this report, a significant difference means that there was a less than 0.05 probability of finding a greater value of F for the given effect. This is the way significance is reported using the PSTAT computer program for the analysis of variance (PSTAT, 1990).

Table 2. Levels for analysis of variance.

Level	Hypothesis tested	Levels
Site (composites from six sites and a field blank)	Are there differences among the sites?  There are three sites upstream (U) and three sites downstream (D) from the mine.	1. Above Farncomb Gulch (U) 2. Above Mineral Hill (U) 3. Above Country Boy Mine (U) 4. Below Ford Gulch (D) 5. Above Gibson Gulch (D) 6. At mouth (D)
Sample (2 aliquots from each composite)	Are there differences between sequential aliquots from the same sample?	Pairs of aliquots from each sample .
Filtrate (3 filtrates for each sample)	Are there differences among filtration treatments?	1. Ultrafiltrate (0.001 $\mu\text{m}$ ) 2. 0.1- $\mu\text{m}$ filtrate 3. 0.45- $\mu\text{m}$ filtrate
Analytical/Error (2 determinations for each bottle)	Are there differences between analytical determinations of the same sample?	Differences due to analytical procedures and error

## **RESULTS**

### **DISSOLVED METAL CONCENTRATIONS**

Few manufacturers produce all the pore-size membranes covered in this test. It is important, however, not to mix different filtration technologies to test the effects of pore size. For example, using an in-line capsule filter for the 0.45- $\mu\text{m}$  filtrate, a pressure filtration for the 0.1- $\mu\text{m}$  filtrate, and tangential flow filtration for the ultrafiltrate would introduce variability that could mask effects due to pore size (Horowitz and others, 1992). To avoid the additional variability, tangential-flow filtration, varying only the membrane size, was chosen because it allowed everything to remain constant in the filtration process except the filter pore size, giving a better control on the pore-size factor.

#### **Significance of differences in filtrate concentrations**

Three filtration treatments were applied to samples that were collected during snowmelt runoff in French Gulch when the amount of colloidal material generally is greatest (Kimball and others, 1995).

Determinations of metal concentrations in these filtrates are listed in Appendix I. Results of the analysis of variance are listed in tables 2 and 3.

#### **Iron**

Statistical significance of the various filtration treatments is very clear from the analysis of variance (table 2). In the first set of results, there is a significant difference among sites. This difference is between sites upstream and downstream from the mine (fig. 2). The effect of filtration is also significant. The cross factor is significant, meaning that the effect of filtration is significant at some sites, but not at others. Results indicate that filtration is significant downstream from the mine. Colloids form with the inflow of iron downstream from the mine general, making filtration of great consequence.

There was a second analysis using the filtration treatment as the main factor, but including a factor for taking replicate samples from the larger sample bottle. This analysis indicated that there was a significant difference for the filtration treatments, but that there was no significant difference between replicates.

There also was no significant difference for the cross factor, indicating that this was true for all the sites.

## **Zinc**

Results for the analysis of variance using zinc concentration as the dependent variable were similar to those using iron concentration (Table 3). There were significant differences among the sites, among the filtrates, and for the cross factor of sites by filtrates. The magnitude of differences, even though it was significant, was much less than for Fe, and also the difference between unfiltered and filtered samples is not as great (fig. 3). Also the difference between filtrate concentrations and unfiltered concentrations is not as great as the differences for Fe.

## **Other Metals**

There are substantial concentrations of Mn from the mining in French Gulch. The three filtrate concentrations for Mn (fig. 4) indicate very little difference. Although there is a significant difference among sites for Mn concentrations, there is not a significant difference among filtrates.

Cadmium concentrations are low, almost at the level of detection. There was a significant difference, however, among sites (fig. 5). There was not a significant difference among filtrates.

## COLLOIDAL METAL CONCENTRATIONS

The concentration of metals in a colloidal phase is calculated indirectly by subtracting the ultrafiltrate concentration from the unfiltered concentration. Iron (fig. 6) is the main component of the colloids; the colloids result from the precipitation of hydrous iron oxides and the subsequent aggregation of those colloids (Grundl and Delwiche, 1993; Kimball and others, 1995; Broshears and others, 1996). This indirect method of measuring colloidal metal concentrations can indicate the concentrations of iron and zinc (fig. 7) in the colloids, but cannot distinguish the concentrations of manganese and cadmium.

## **DISCUSSION**

These results indicate the presence of colloidal Fe with associated metal concentrations. The colloidal Fe is a direct result of the introduction of metals from the mine in French Gulch; there was no significant colloidal Fe upstream from the mine.

Iron and Zn are the principal metals in the colloids, but there are likely substantial concentrations of Cd, Cu, and Pb. A direct measurement of colloidal concentrations of these less abundant metals, rather than the indirect measurement used here, would give an indication of their concentrations (Kimball and others, 1995).

## **FILTRATION FOR DISSOLVED CONCENTRATIONS**

The significant difference among filtrate concentrations indicates that colloidal Fe does pass through 0.1- and 0.45- $\mu$ m filters. Although there was not a great difference between the filtrate concentrations for these larger pore-sized filters, they are both substantially greater than the ultrafiltrate concentrations.

## **IMPLICATIONS OF FILTRATION RESULTS**

Using the 0.45- $\mu$ m filtration will result in higher “dissolved” concentrations for Fe, Zn, and possibly Cd, Cu, and Pb than may actually be present. When assessing the risk or toxicity of metal contamination with 0.45- $\mu$ m filtered concentrations, this filtration effect would cause an overestimate of risk. This is an error on the side of safety. The presence of colloidal metals may also be a source of toxicity for aquatic organisms. A recent study indicated that colloidal metals might be re-dissolved in fish guts, becoming available to the fish (Mayer and others, 1996). There should be more study of the particular pathways by which colloidal metals might affect the chronic toxicity of aquatic organisms.

Any geochemical modeling using data from the 0.45- $\mu$ m filtration could be in error also, particularly with respect to any calculations regarding saturation of Fe phases. This could influence studies about the

geochemical and biological processes that affect the metals in surface and ground water affected by mining.



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Appendix I—Results of determinations of metals in various filtrates and unfiltered samples from French Gulch, Colorado. All concentrations are in milligrams per liter.

[Snum, downstream site number; Rnum, replicate sample number; Fnum, filter number; Al, aluminum; Cd, cadmium; Cu, copper; Fe, iron; Mn, manganese; Zn, zinc; Ab, above; bdl, below detection limit.]

Site	Snum	Rnum	Fnum	Filter	Al	Cd	Cu	Fe	Mn	Zn
Ab Farncomb	1F	1	1	0.001	bdl	0.001	0.007	0.001	0.002	0.041
					0.007	bdl	0.003	0.002	0.002	0.018
			2	0.1	bdl	bdl	0.004	0.009	0.000	0.013
			3	0.45	0.023	bdl	0.005	0.009	0.001	0.013
		2	4	1	0.049	0.000	0.003	0.062	0.003	0.008
			1	0.001	0.006	0.000	0.006	0.002	0.001	0.027
			2	0.1	bdl	0.000	0.001	0.010	0.001	0.019
			3	0.45	0.046	bdl	0.003	0.010	0.001	0.023
					0.024	0.000	bdl	0.017	0.002	0.024
					0.020	0.000	0.004	0.012	0.001	0.029
					0.023	bdl	0.001	0.007	0.001	0.021
			4	1	0.074	bdl	0.003	0.053	0.003	0.015
					0.070	bdl	0.002	0.053	0.003	bdl
Ab Mineral	2F	1	1	0.001	bdl	bdl	0.005	bdl	0.004	0.066
			2	0.1	0.000	0.002	0.006	0.017	0.004	0.033
			3	0.45	0.026	bdl	0.004	0.012	0.004	0.047
					0.046	bdl	0.001	0.010	0.005	0.035
		2	4	1	0.039	bdl	0.004	0.075	0.008	0.013
			1	0.001	bdl	0.001	0.007	0.005	0.005	0.070
			2	0.1	0.020	0.001	0.006	0.018	0.005	0.050
			3	0.45	0.020	0.002	0.004	0.018	0.004	0.059
			4	1	0.063	bdl	0.003	0.076	0.008	0.009
					0.063	bdl	0.003	0.076	0.008	0.009
Ab Country Bo	3F	1	1	0.001	bdl	bdl	0.006	0.005	0.001	0.035
			2	0.1	0.023	bdl	0.002	0.014	0.002	0.029
					bdl	0.000	0.005	0.013	0.002	0.018
					0.039	0.000	0.004	0.017	0.002	0.017
			3	0.45	0.057	bdl	0.002	0.021	0.002	0.038
					0.039	bdl	0.004	0.015	0.002	0.038
					0.029	0.001		0.011	0.002	0.045
			4	1	0.102	bdl	0.002	0.085	0.007	0.039
		2			0.104	bdl	0.001	0.087	0.006	0.034
			1	0.001	0.054	0.000	0.001	0.002	0.002	0.024
					bdl	bdl	0.003	0.000	0.002	0.030
			2	0.1	bdl	0.003	0.006	0.020	0.002	0.020
					bdl	bdl	0.005	0.009	0.001	0.023
					0.057	0.001	0.000	0.006	0.002	0.036
			3	0.45	0.020	bdl	0.005	0.006	0.002	0.043
			4	1	0.082	bdl	0.003	0.084	0.007	0.048

Appendix I—Results of determinations of metals in various filtrates and unfiltered samples from French Gulch, Colorado. All concentrations are in milligrams per liter.

Site	Snum	Rnum	Fnum	Filter	Al	Cd	Cu	Fe	Mn	Zn
Ab Country Bo	3F	2	4	1	0.095	0.000	0.004	0.080	0.007	0.040
Below Ford	4F	1	1	0.001	0.040	0.003	0.002	0.002	0.246	0.870
					bdl	0.003	0.001	0.002	0.250	0.850
			2	0.1	0.047	0.001	0.004	0.162	0.257	0.888
					0.056	0.003	0.002	0.155	0.263	0.959
			3	0.45	0.065	0.005	0.003	0.171	0.267	1.035
					0.067	0.000	0.003	0.164	0.261	1.030
			4	1	0.261	0.004	0.007	0.488	0.283	1.126
					0.243	0.002	0.004	0.509	0.295	1.159
		2	1	0.001	0.025	0.005	0.005	0.005	0.254	0.729
					0.054	0.004	0.004	0.006	0.253	0.766
					bdl	0.005	0.003	0.010	0.245	0.853
			2	0.1	0.039	0.002	0.003	0.158	0.253	0.798
					0.056	0.003	0.005	0.164	0.254	0.816
			3	0.45	0.045	0.005	0.002	0.177	0.258	0.904
					0.076	0.005	0.005	0.177	0.267	0.943
			4	1	0.289	0.005	0.008	0.560	0.293	1.164
					0.292	0.001	0.005	0.545	0.299	1.177
Above Gibson	5F	1	1	0.001	0.055	0.002	0.005	0.000	0.441	1.601
					0.007	0.005	0.003	0.000	0.444	1.654
			2	0.1	0.034	0.007	0.003	0.230	0.468	1.795
			3	0.45	0.068	0.005	0.004	0.260	0.480	1.867
					0.055	0.005	0.003	0.248	0.465	1.849
			4	1	0.309	0.006	0.004	0.837	0.512	2.144
					0.392	0.010	0.006	0.949	0.520	2.146
		2	1	0.001	0.027	0.005	0.003	0.010	0.438	1.456
			2	0.1	0.036	0.005	0.003	0.250	0.464	1.687
					0.038	0.004	0.003	0.233	0.472	1.695
			3	0.45	0.066	0.003	0.003	0.276	0.472	1.797
			4	1	0.312	0.007	0.004	0.830	0.515	1.928
		3	2	0.1	0.030	0.004	0.003	0.000	0.381	1.250
					0.185	0.005	0.003	0.389	0.425	1.754
			3	0.45	0.036	0.004	0.003	0.075	0.399	1.350
					0.058	0.007	0.004	0.072	0.413	1.492
			4	1	0.184	0.004	0.004	0.392	0.423	1.766
At mouth	6F	1	1	0.001	0.031	0.004	0.007	bdl	0.296	1.758
					0.049	0.006	0.008	0.005	0.293	1.810
					0.013	0.009	0.012	0.004	0.294	1.741
			2	0.1	0.031	0.006	0.003	0.102	0.310	2.144
					0.019	0.005	0.003	0.106	0.314	2.188
					bdl	0.004	0.006	0.103	0.316	2.226
			3	0.45	0.048	0.006	0.002	0.120	0.328	2.490

Appendix I—Results of determinations of metals in various filtrates and unfiltered samples from French Gulch, Colorado—continued.

Site	Snum	Rnum	Fnum	Filter	Al	Cd	Cu	Fe	Mn	Zn
At mouth	6F	1	3	0.45	0.024	0.006	0.007	0.122	0.325	2.434
			4	1	0.108	0.009	0.006	0.256	0.323	2.541
					0.112	0.006	0.005	0.246	0.326	2.580
					0.108	0.006	0.004	0.262	0.338	2.585
		2	1	0.001	0.067	0.008	0.004	bdl	0.301	2.100
					bdl	0.004	0.005	0.004	0.307	2.157
			2	0.1	0.062	0.008	0.004	0.108	0.317	2.202
					0.002	0.009	0.004	0.097	0.323	2.384
			3	0.45	0.064	0.009	0.005	0.123	0.322	2.437
					0.050	0.008	0.004	0.113	0.320	2.448
			4	1	0.048	0.006	0.005	0.129	0.323	2.395
					0.097	0.008	0.006	0.251	0.333	2.536
					0.110	0.007	0.006	0.242	0.319	2.588

Table 3. -Results of Multi-factorial analysis of variance.

[DF, degrees of freedom; SS, sum of squares; MS, mean square, F, F-ratio;  
Pr>F, probability of a greater F value.]

SOURCE OF VARIATION	DF	SS	MS	F	Pr>F
MINE	1	.1321795979	.1321795979	105.32	.0001
FNUM	2	.1077064087	.0538532044	42.91	.0001
MINE*FNUM	2	.0693330377	.0346665188	27.62	.0001
Residual	48	.0602413855	.0012550289		
Adjusted Total	53	.3694604298			

SOURCE OF VARIATION	DF	SS	MS	F	Pr>F
SNUM	5	.1679609518	.0335921904	1029.85	.0001
FNUM	2	.1100795720	.0550397860	1687.38	.0001
FNUM*SNUM	10	.0902456391	.0090245639	276.67	.0001
Residual	36	.0011742670	.3261853E-4		
Adjusted Total	53	.3694604298			

SOURCE OF VARIATION	DF	SS	MS	F	Pr>F
SNUM	5	.1679609518	.0335921904	7.10	.0001
RNUM	1	.8784064E-5	.8784064E-5	.00	.9658
SNUM*RNUM	5	.0027303230	.0005460646	.12	.9883
Residual	42	.1987603710	.0047323898		
Adjusted Total	53	.3694604298			

SOURCE OF VARIATION	DF	SS	MS	F	Pr>F
FNUM	2	.0896908246	.0448454123	7.80	.0012
RNUM	1	.0018335748	.0018335748	.32	.5750
FNUM*RNUM	2	.0018429005	.0009214503	.16	.8524
Residual	48	.2760931299	.0057519402		
Adjusted Total	53	.3694604298			

Unpublished Records  
Subject to Revision

Number of Observations 54

ANALYSIS OF VARIANCE: ZN  
in File: ZNANOVA

SOURCE OF VARIATION	DF	SS	MS	F	Pr>F
SNUM	5	43.96254945	8.792509890	1284.47	.0001
FNUM	2	.2760803316	.1380401658	20.17	.0001
FNUM*SNUM	10	.3546936933	.0354693693	5.18	.0001
Residual	36	.2464283197	.0068452311		
Adjusted Total	53	44.83975179			

① Site yes  
② Site no  
③ Cross

GRAND MEAN .9056555556  
Number of Observations 54ANALYSIS OF VARIANCE: ZN  
in File: ZNANOVA

SOURCE OF VARIATION	DF	SS	MS	F	Pr>F
SNUM	5	43.96254945	8.792509890	472.06	.0001
RNUM	1	.0008108149	.0008108149	.04	.8357
SNUM*RNUM	5	.0941059954	.0188211991	1.01	.4236
Residual	42	.7822855342	.0186258461		
Adjusted Total	53	44.83975179			

① Site yes  
② Site no  
③ Cross

GRAND MEAN .9056555556  
Number of Observations 54ANALYSIS OF VARIANCE: ZN  
in File: ZNANOVA

SOURCE OF VARIATION	DF	SS	MS	F	Pr>F
FNUM	2	.1338552921	.0669276461	.07	.9298
RNUM	1	.5250603339	.5250603339	.57	.4532
FNUM*RNUM	2	.1131533607	.0565766803	.06	.9403
Residual	48	44.06768281	.9180767251		
Adjusted Total	53	44.83975179			

① R.H. no  
② R.H. yes  
③ Cross

GRAND MEAN .9056555556  
Number of Observations 54Sort on 54 cases completed.  
File ZNANOVA was already in sort order.PERCENTILES completed.  
54 cases were read from file ZNANOVA.



## **FIGURE CAPTIONS**

Figure 1—Schematic map of French Gulch, Colorado indicating the location of sampling sites in relation to the Wellington-Oro Mine.

Figure 2—Mean iron concentration for each filtration treatment at sites in French Gulch, Colorado.

Figure 3—Mean zinc concentration for each filtration treatment at sites in French Gulch, Colorado.

Figure 4—Mean manganese concentration for each filtration treatment at sites in French Gulch, Colorado.

Figure 5—Mean cadmium concentration for each filtration treatment at sites in French Gulch, Colorado.

Figure 6—Dissolved (ultrafiltrate) versus colloidal iron concentrations at sites in French Gulch, Colorado.

Figure 7—Dissolved (ultrafiltrate) versus colloidal zinc concentrations at sites in French Gulch, Colorado.

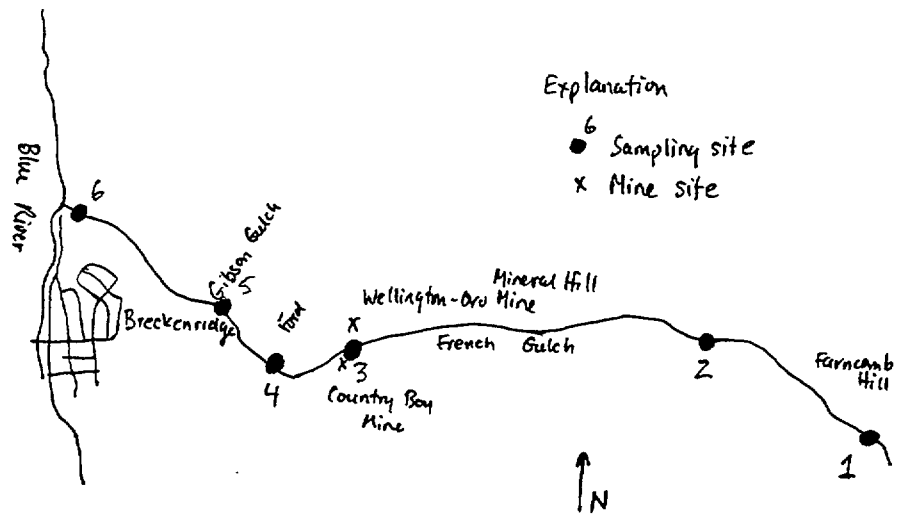
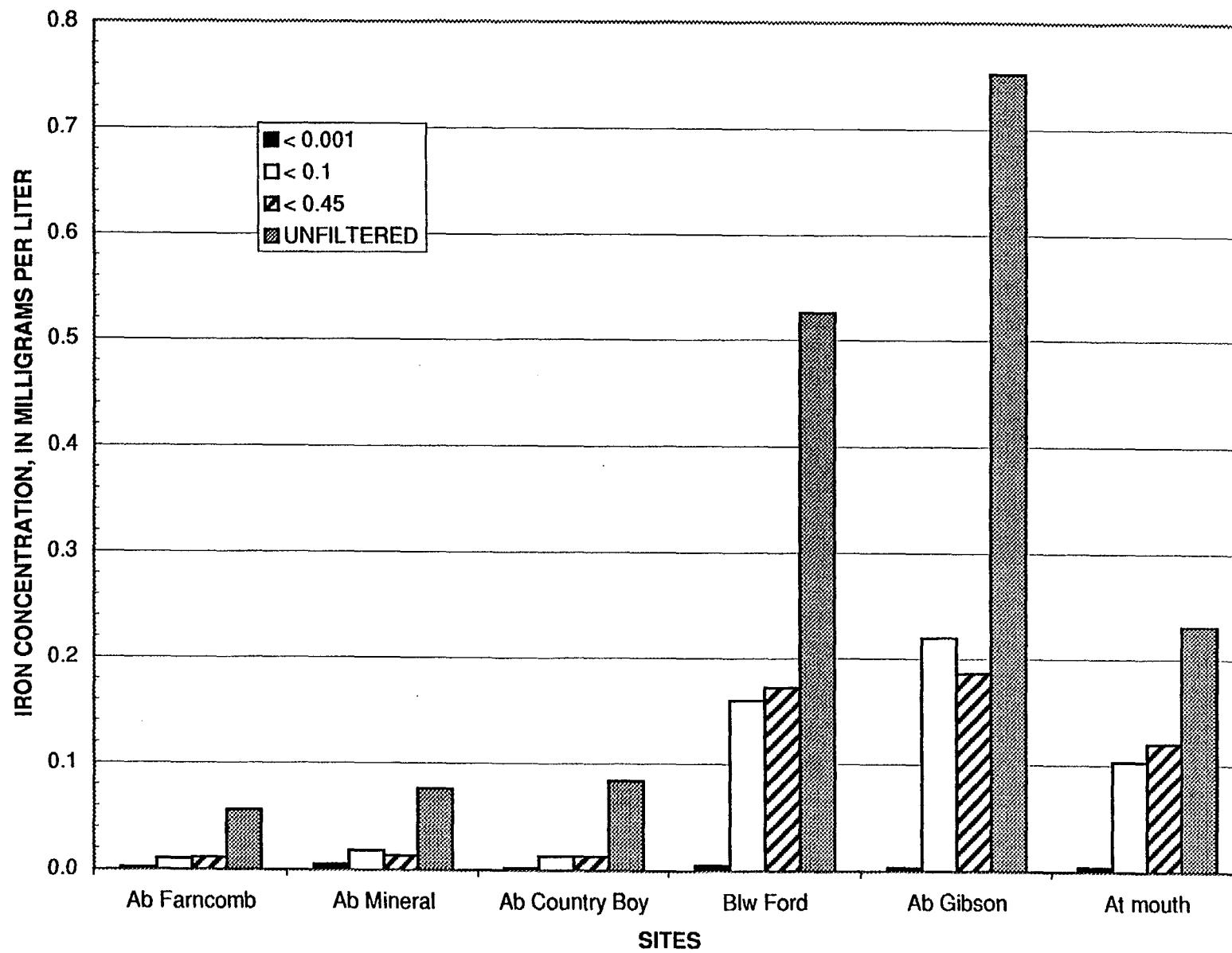
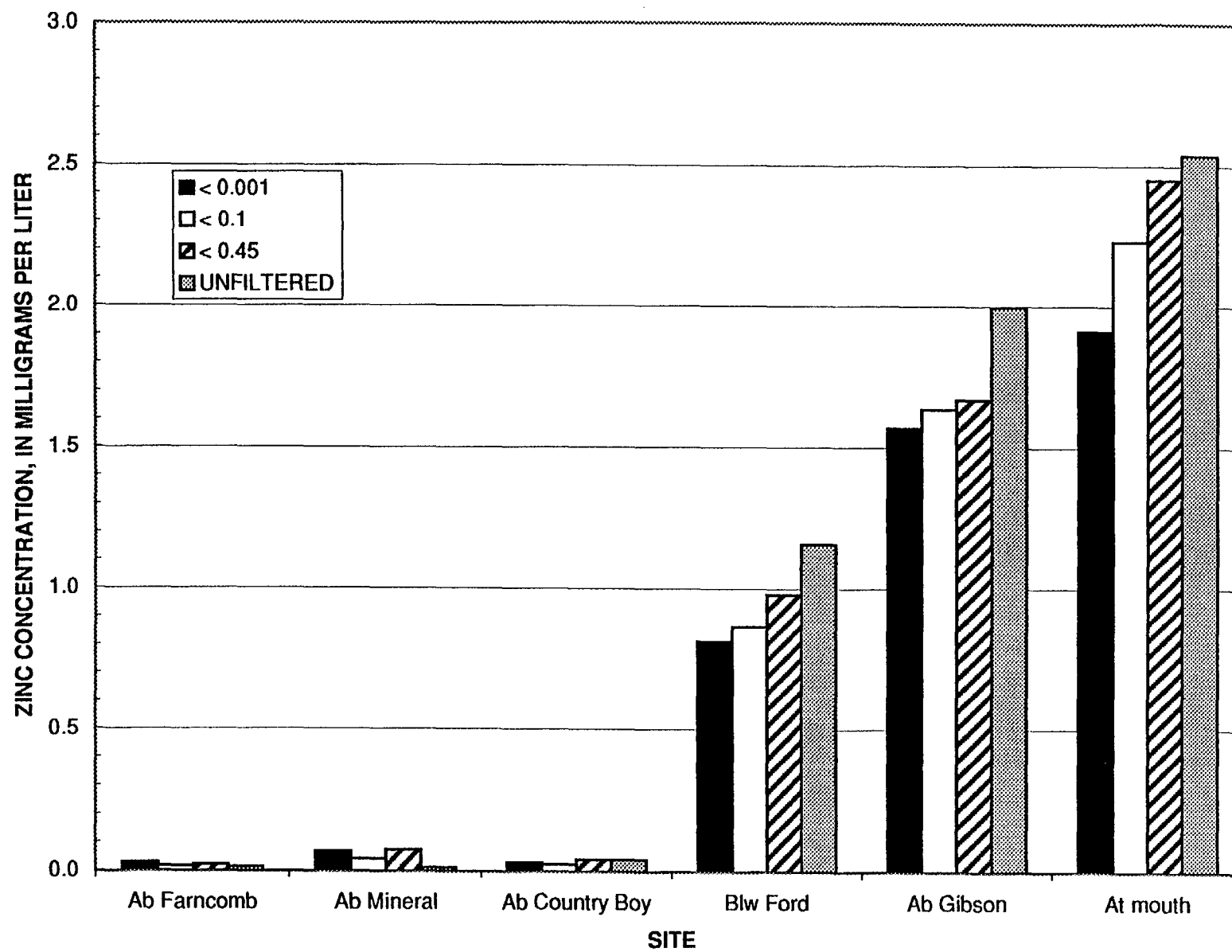


Figure 1



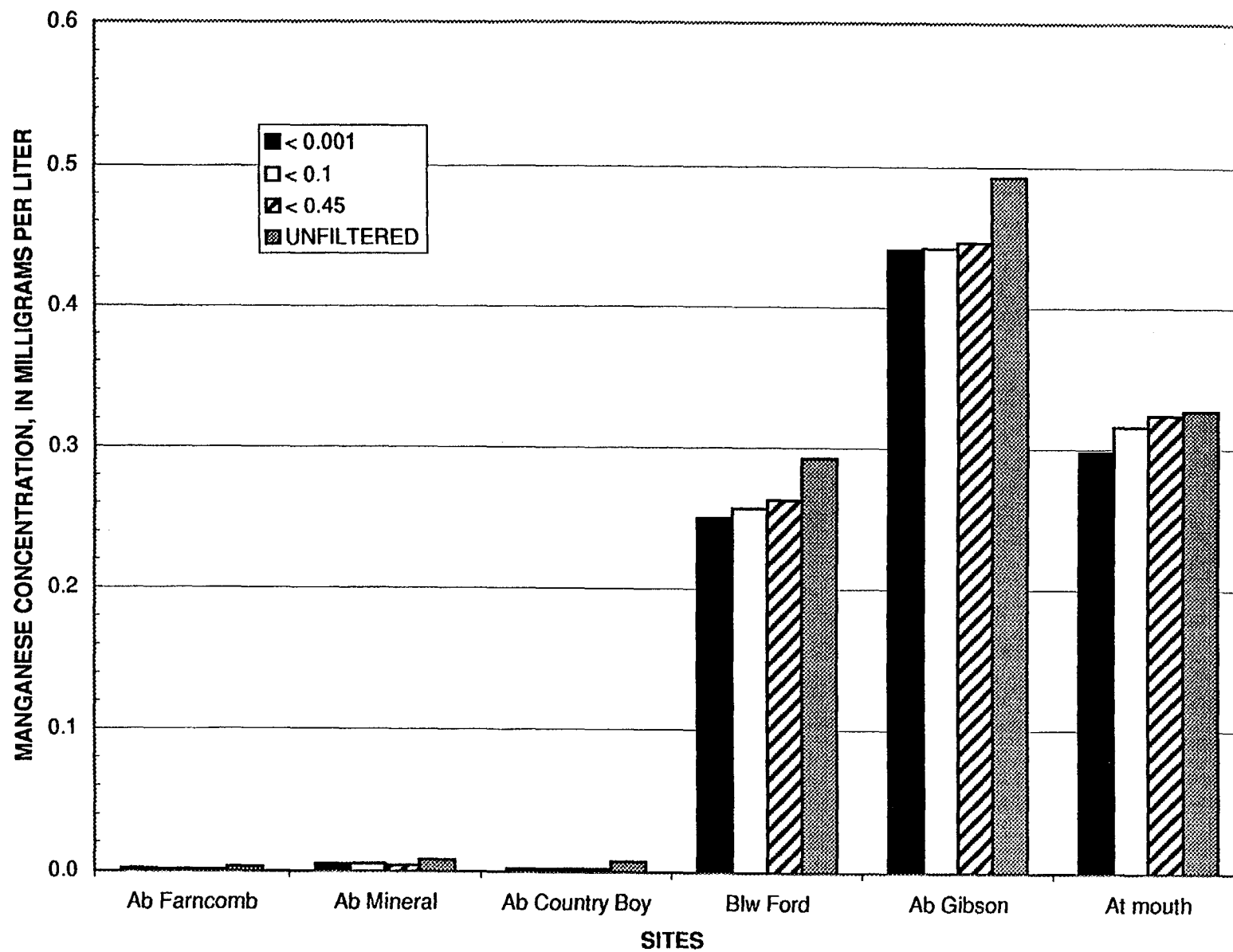
Unpublished Records  
Subject to Revision

Figure 2



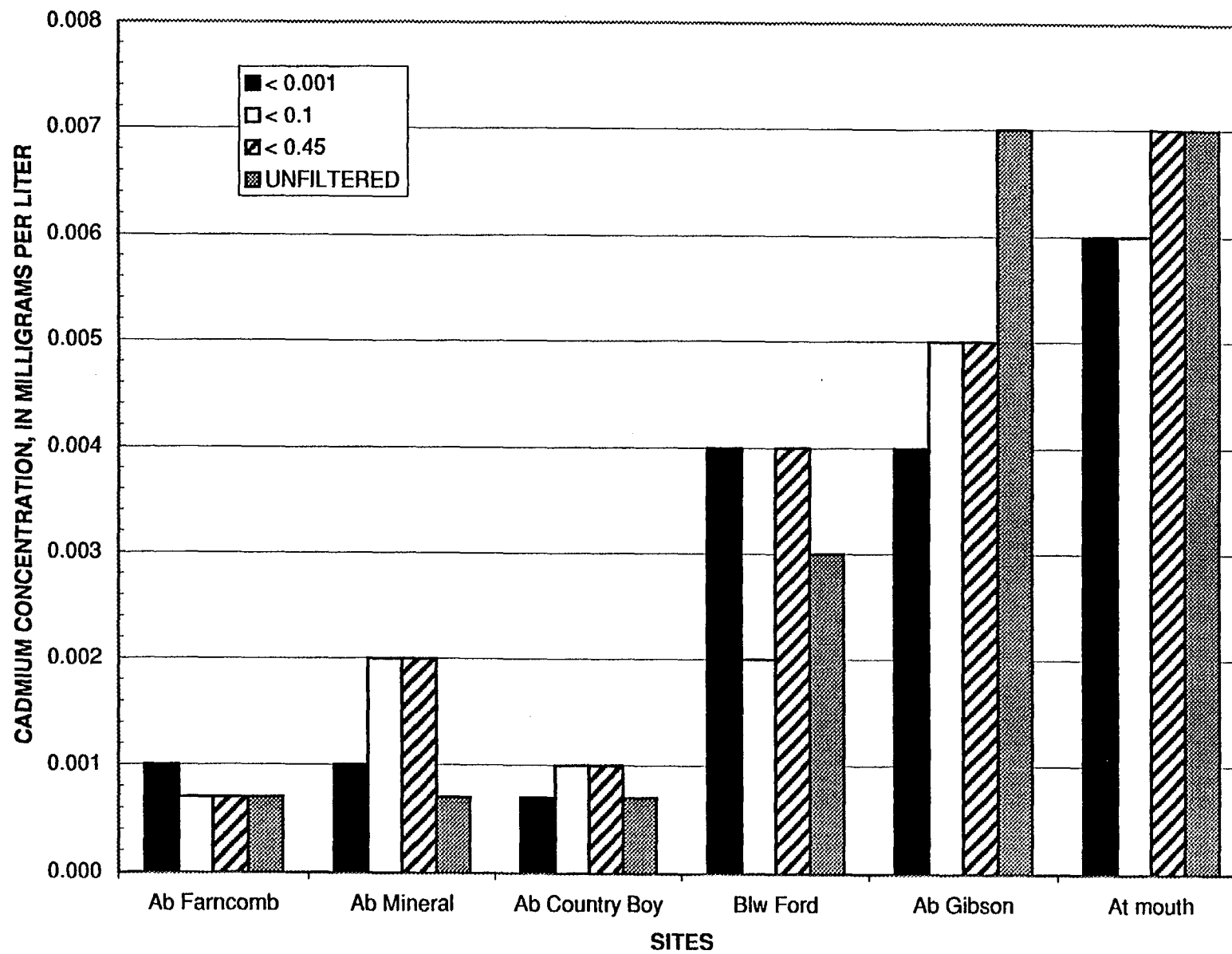
Unpublished Records  
Subject to Revision

Figure 3



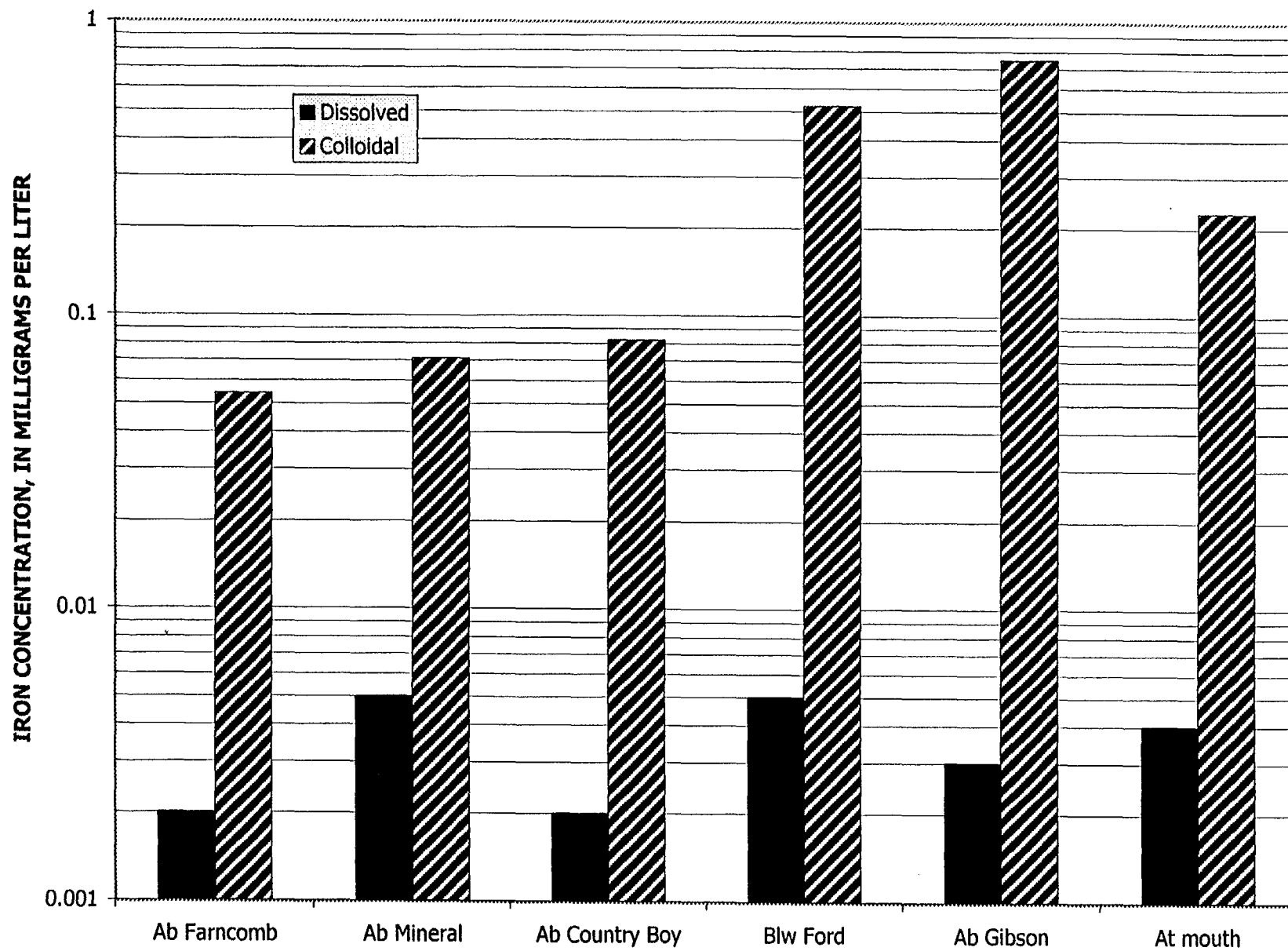
Unpublished Records  
Subject to Revision

Figure 4



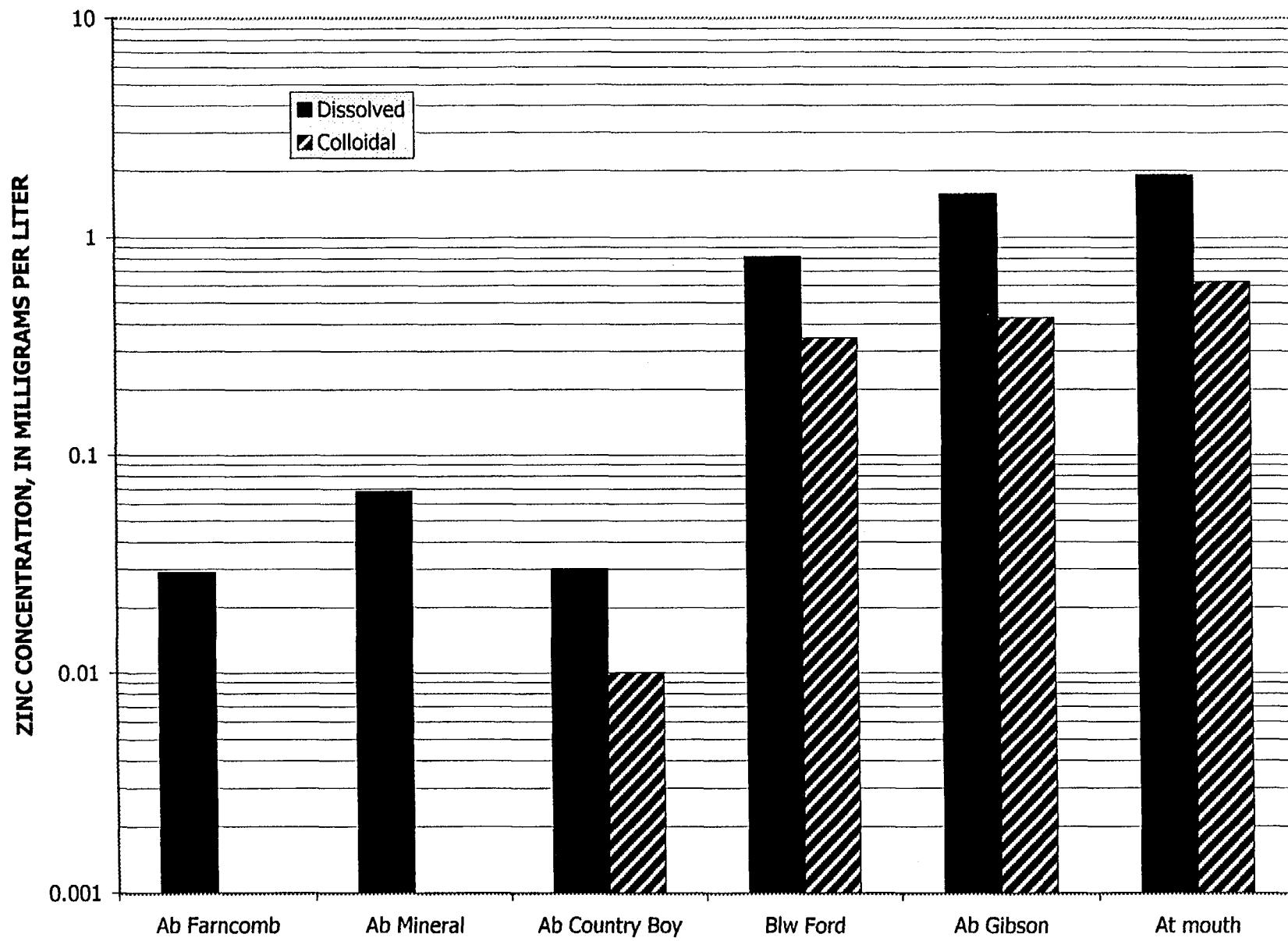
Unpublished Records  
Subject to Revision

Figure 5.



Unpublished Records  
Subject to Revision

Figure 6



Unpublished Records  
Subject to Review

Figure 7



## **Appendix 3-2**

Table 1:

French Gulch Nonpoint Source Study. Water Quality data collected May 3-4, 1989.

Note: Underlined values exceed Colorado chronic table values for cold water class I streams.

Site	Flow cfs	Sus. solids mg/l	Alk. mg/l	Tot. Hard. mg/l	pH	N-ammonia mg/l	N-nitrite/nitrate mg/l	Phos-tot. mg/l	Cd-t ug/l	Cd-d ug/l	Cu-t ug/l	Cu-d ug/l	Fe-t ug/l
FG1	1.96	*	47	69	7.20	NS	NS	NS	*	*	*	*	*
Mcleod Tunnel	.024	40	129	160	7.97	NS	NS	NS	1.2	NS	*	NS	<u>2700</u>
FG2	2.61	*	49	67	7.70	NS	NS	NS	*	*	*	*	*
FG2 spring	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
FG3	1.26	*	55	73	7.56	NS	NS	NS	*	NS	*	NS	*
FG4	.011	510	0	190	<u>3.74</u>	NS	NS	NS	72	NS	70	NS	<u>16000</u>
FG5	4.04	*	59	84	7.42	NS	NS	NS	*	*	*	*	*
FG6	.039	43	0	300	<u>4.37</u>	NS	NS	NS	61	NS	*	NS	<u>3700</u>
FG6A	.422	36	23	580	<u>6.33</u>	NS	NS	NS	29	<u>25</u>	22	11	<u>28000</u>
FG7	2.44	*	41	200	6.90	NS	NS	NS	12	<u>12</u>	*	*	<u>1200</u>
FG8	3.42	*	50	97	7.18	NS	NS	NS	2	<u>1.8</u>	*	*	*
FG9	6.80	*	39	140	6.85	*	*	*	8.2	<u>7.1</u>	*	*	330
BR1	9.15	16	50	67	7.51	*	*	*	.44	.30	6	7	770
BR2	6.19	*	40	140	6.90	*	*	*	6	<u>6</u>	*	*	280
BR3	41.74	*	50	80	7.46	*	*	*	.40	.40	*	*	*

NS = Not sampled

\* = Below CDH Laboratory detection limits (k.30ug/l Cd, k 5 ug/l Cu, k 100 ug/l Fe, k 5 ug/l Pb,  
k 50 ug/l Mn, k .20 ug/l Ag, k 10 ug/l Zn, k 10 mg/l Sus. solids)

Table 1: French Gulch May 3-4, 1989 water quality (cont.)

Site	Pb-t ug/l	Pb-d ug/l	Mn-t ug/l	Hg mg/l	Ag-t ug/l	Ag-d ug/l	Zn-t ug/l	Zn-d ug/l
FG1	*	*	*	NS	*	*	*	*
McLeod Tunnel	18	NS	<u>1000</u>	NS	*	NS	490	*
FG2	*	*	*	NS	*	*	*	10
FG2 spring	NS	NS	NS	NS	NS	NS	10	NS
FG3	*	NS	*	NS	*	NS	20	NS
FG4	360	NS	<u>1400</u>	NS	*	NS	9600	NS
FG5	*	*	*	NS	*	*	20	10
FG6	270	NS	<u>4900</u>	NS	.34	NS	17000	NS
FG6A	82	*	<u>17000</u>	NS	.33	.30	51000	<u>49000</u>
FG7	5	*	<u>3900</u>	NS	*	*	14000	<u>9300</u>
FG8	*	*	*	NS	*	*	660	<u>650</u>
FG9	6	*	740	*	*	*	4400	<u>4500</u>
BR1	8	*	*	NS	*	*	110	<u>60</u>
BR2	5	*	710	NS	*	*	4300	<u>4200</u>
BR3	*	*	*	NS	*	*	70	<u>80</u>

ND : No data

\* : Below CDH Laboratory Detection limits (k 0.30 ug/l Cd, k 5 ug/l Cu, k 100 ug/l Fe, k 5 ug/l Pb,  
k 50 ug/l Mn, k .20 ug/l Ag, k 10 ug/l Zn, k 10 mg/l Sus. solid)

Table 2:  
French Gulch Nonpoint Source Study. Metals mass balance in grams per day, May 3-4 1989 data.

Site	Cd-t g/day	Cd-d g/day	Cu-t g/day	Cu-d g/day	Fe-t g/day	Pb-t g/day	Pb-d g/day	Mn-t g/day	Hg g/day	Ag-t g/day	Ag-d g/day	Zn-t g/day	Zn-d g/day
FG1	*	*	*	*	*	*	*	*	NS	*	*	*	*
McLeod Tunnel	0.1	NS	*	NS	159.2	1.1	NS	59.0	NS	*	NS	28.9	*
FG2	*	*	*	*	*	*	*	*	NS	*	*	*	63.9
FG3	*	NS	*	NS	*	*	NS	*	NS	*	NS	61.7	NS
FG4	1.9	NS	1.9	NS	430.7	9.7	NS	37.7	NS	*	NS	258.4	NS
FG5	*	*	*	*	*	*	*	*	NS	*	*	197.7	98.8
FG6	5.8	NS	*	NS	353.1	25.8	NS	467.6	NS	.32	NS	1622.4	NS
FG6A	29.9	25.8	22.7	11.4	28913.8	84.7	*	17554.8	NS	.34	.31	52664.3	50599.1
FG7	71.6	71.6	*	*	7164.8	29.8	*	23285.6	NS	*	*	83589.5	55527.3
FG8	16.7	15.1	*	*	*	*	*	*	NS	*	*	5523.4	5439.7
FG9	136.4	118.1	*	*	5491.1	99.8	*	12313.3	*	*	*	73214.2	74878.2
BR1	9.8	6.7	134.3	156.7	17240.3	179.1	*	*	NS	*	*	2462.9	1343.4
BR2	90.9	90.9	*	*	4241.1	75.7	*	10754.3	NS	*	*	65131.8	63617.1
BR3	40.9	40.9	*	*	*	*	*	*	NS	*	*	7149.6	8171.0

\* = Instream concentrations were below CDH detection limits. See Table 1.

NS = not sampled

Table 3:  
French Gulch Nonpoint Source Study. Water quality data collected Sept. 20-21, 1989.

Note: Underlined values exceed Colorado chronic table values for cold water class 1 streams.

Site	Flow cfs	Sus. solids mg/l	Alk. mg/l	Tot. Hard. mg/l	pH	Al-t mg/l	Al-d mg/l	Cd-t ug/l	Cd-d ug/l	Cu-t ug/l	Cu-d ug/l	Fe-t ug/l	Pb-t ug/l	Pb-d ug/l
FG0	2.63	NS	32	58	6.66	*	*	*	*	*	*	*	*	*
FG2	4.24	NS	84	60	6.72	*	*	*	*	*	*	*	*	*
FG2 spring	NS	NS	NS	NS	NS	*	NS	*	NS	*	NS	*	*	NS
FG4	2.27	*	100	58	6.69	*	*	*	*	*	*	*	*	*
FG6A	0.189	40	36	656	<u>5.23</u>	*	*	31	<u>43</u>	6	*	<u>66000</u>	33	*
FG8	3.42	NS	98	92	<u>6.17</u>	*	*	2	<u>1.9</u>	*	*	*	*	*
FG9	4.80	NS	46	102	<u>5.84</u>	*	*	4.3	<u>4.3</u>	*	*	140	*	*
BR1	2.76	NS	56	58	<u>6.41</u>	*	*	*	*	*	*	*	*	*
BR2	4.04	NS	42	108	<u>6.10</u>	*	*	4.4	<u>4.3</u>	*	*	140	*	*
BR3	24.39	NS	40	68	6.64	*	*	0.5	0.4	*	*	*	*	*

NS = Not sampled

\* = Below CDH Laboratory detection limits (k.30ug/l Cd, k 5 ug/l Cu, k 100 ug/l Fe, k 5 ug/l Pb,  
k 50 ug/l Mn, k .20 ug/l Ag, k 10 ug/l Zn, k 10 mg/l Sus. solids)

Table 3: Continued

Site	Mn-t ug/l	Ni-t ug/l	Ni-d ug/l	Hg ug/l	Ag-t ug/l	Ag-d ug/l	Zn-t ug/l	Zn-d ug/l
FG0	*	NS	NS	*	*	*	*	*
FG2	*	NS	NS	NS	*	*	10	*
FG2 spring	*	NS	NS	NS	*	NS	*	NS
FG4	*	NS	NS	NS	*	*	*	*
FG6A	26000	*	*	NS	*	*	66000	7000
FG8	*	NS	NS	NS	*	*	470	460
FG9	460	NS	NS	*	*	*	1900	1900
BR1	*	*	*	NS	*	*	10	*
BR2	520	*	*	NS	*	*	2200	1700
BR3	*	NS	NS	ND	*	*	70	50

French Gulch Nonpoint Source Study. Metals mass balance Sept. 20-21, 1989 data.

[illegible]

Table 5:  
*Ceriodaphnia* spp. 48 hr. acute toxicity test.  
 Bioassay water quality. Samples collected June 5, 1989.

All metals reported as dissolved fraction.

Site	pH	T. alk. mg/l	T. hard. mg/l	N-nitrate/nitrite	N-ammonia	T-phos.	Al ug/l	Cd ug/l	Cu ug/l	Fe ug/l	Pb ug/l	Mn ug/l	Ag ug/l	Zn ug/l
FG0	7.3	30	38	ND	ND	ND	*	*	*	*	*	*	*	*
FG1	7.4	32	40	ND	ND	ND	*	*	*	*	*	*	*	*
FG5	7.5	32	44	ND	ND	ND	*	*	*	*	*	*	*	40
FG6A	6.2	14	0	ND	ND	ND	*	23	*	22000	*	11000	*	32000
FG9	7.2	40	70	ND	ND	ND	*	3.8	*	180	*	360	*	2000
BR1	7.8	50	56	*	*	*	*	*	*	*	*	*	*	30
BR2	7.4	46	60	*	*	*	*	1.2	*	*	*	120	*	620
BR3	7.6	48	62	*	*	*	*	0.4	*	*	*	*	*	80

ND = No data

\* = Below CDH laboratory detection limits.



Table 6:  
Preliminary fish electroshocking data collected Sept. 20-21, 1989.

Site	Number Collected
FG0	4 Colorado cutthroat trout
FG1	2 Colorado cutthroat trout
FG2	5 Colorado cutthroat trout
FG4	0
FG6A	0
FG8 (S. channel)	0
FG9	0
BR1	1 brown trout 1 brook trout
BR2	1 rainbow trout
BR3	118 brown trout 26 brook trout 1 sculpin

# FRENCH GULCH CHEMISTRY DATA: SEPTEMBER 22, 1992

Sampling Station	Sample Collection Date & Time	Field Measurements				Tot. Alk. mg/l	HCO <sub>3</sub> <sup>-</sup> Alk. mg/l	CO <sub>3</sub> <sup>-2</sup> Alk. mg/l	HCO <sub>3</sub> <sup>-</sup> mg/l	TSS mg/l
		Q cfs	Temp °C	Cond. µmhos/cm	pH su					
FG-0	9/22/92 @1345	2.46	10.1	76	6.79	29.43	29.42	0.006	35.9	5
FG-1	9/22/92 @1320	2.96	9.5	80	6.87	36.54	36.52	0.022	44.6	1
FG-2	9/22/92 @1305	3.67	9.0	83	6.91	36.54	36.53	0.012	44.6	5
FG-3	9/22/92 @1245	3.45	10.0	92	6.89	44.66	44.65	0.008	54.5	4
FG-4	9/22/92 @1225	3.36	10.0	90	6.93	43.64	43.63	0.010	53.2	2
FG-5	9/22/92 @1200	3.57	6.9	95	6.83	40.60	40.59	0.009	49.5	1
FG-6A	9/22/92 @1130	0.287	10.7	740	6.03	8.12	8.12	0.000	9.9	30
FG-7	9/22/92 @1110	3.57	9.5	158	6.54	44.66	44.65	0.008	54.5	4
FG-8	9/22/92 @1040	1.74	7.9	139	6.69	43.64	43.64	0.004	53.2	2
FG-9	9/22/92 @1612	4.78	11.5	163	7.91	40.63	40.62	0.010	49.5	2
BR-1	9/22/92 @1550	1.22	12.4	98	8.36	53.79	53.78	0.011	65.6	4
BR-2	9/22/92 @1520	5.12	11.2	161	7.98	38.57	38.56	0.006	47.0	3
BR-4	9/22/92 @1250	51.9	11.5	113	8.30	53.79	53.78	0.012	65.6	3
BR-5	9/22/92 @1200	62.1	11.8	110	8.32	51.76	51.74	0.015	63.1	5
SR-1	9/22/92 @1350	4.43	10.2	89	7.71	43.64	43.63	0.008	53.2	7
BLANK 1	9/22/92 @1840	-----	-----	-----	-----	-----	-----	-----	-----	-----
BLANK 2	9/22/92 @1840	-----	-----	-----	-----	-----	-----	-----	-----	-----
BLANK 3	9/22/92 @1840	-----	-----	-----	-----	-----	-----	-----	-----	-----
RECON	9/22/92 @1840	-----	-----	-----	-----	55.82	55.81	0.009	68.1	-----

Note: "-t" = Total Recoverable "-d" = Dissolved

# FRENCH GULCH CHEMISTRY DATA: SEPTEMBER 22, 1992

Sampling Station	Sample Collection Date & Time	F mg/l	Cl mg/l	SO <sub>4</sub> mg/l	NO <sub>3</sub> mg/l	NO <sub>2</sub> mg/l	PO <sub>4</sub> mg/l	Ca mg/l	Mg mg/l	Hardness mg/l
FG-0	9/22/92 @1345	<0.2	<0.5	18.1	<0.5	<0.2	<1	16.97	1.19	47.3
FG-1	9/22/92 @1320	<0.2	<0.5	18.4	<0.5	<0.2	<1	18.88	1.41	52.9
FG-2	9/22/92 @1305	<0.2	<0.5	18.9	<0.5	<0.2	<1	19.34	1.53	54.6
FG-3	9/22/92 @1245	<0.2	<0.5	18.1	<0.5	<0.2	<1	21.73	1.77	61.5
FG-4	9/22/92 @1225	<0.2	<0.5	18.3	<0.5	<0.2	<1	21.35	1.78	60.6
FG-5	9/22/92 @1200	<0.2	<0.5	18.6	<0.5	<0.2	<1	22.01	1.81	62.4
FG-6A	9/22/92 @1130	<0.2	<0.5	551	<0.5	<0.2	<1	122.70	32.45	440
FG-7	9/22/92 @1110	<0.2	<0.5	64.4	<0.5	<0.2	<1	33.08	4.65	102
FG-8	9/22/92 @1040	<0.2	<0.5	54.1	<0.5	<0.2	<1	31.36	3.94	94.5
FG-9	9/22/92 @1612	<0.2	<0.5	66.4	<0.5	<0.2	<1	33.73	4.67	103
BR-1	9/22/92 @1550	<0.2	1.6	9.8	<0.5	<0.2	<1	18.99	4.44	65.7
BR-2	9/22/92 @1520	<0.2	0.6	66.7	<0.5	<0.2	<1	33.41	4.62	102
BR-4	9/22/92 @1250	<0.2	3.6	18.4	<0.5	<0.2	<1	22.00	4.39	73.0
BR-5	9/22/92 @1200	<0.2	2.8	18.6	<0.5	<0.2	<1	21.75	4.25	71.8
SR-1	9/22/92 @1350	<0.2	0.6	17.5	<0.5	<0.2	<1	18.80	3.29	60.5
BLANK 1	9/22/92 @1840	-----	-----	-----	-----	-----	-----	<0.01	<0.01	0.00
BLANK 2	9/22/92 @1840	-----	-----	-----	-----	-----	-----	<0.01	<0.01	0.00
BLANK 3	9/22/92 @1840	-----	-----	-----	-----	-----	-----	0.01	<0.01	0.02
RECON	9/22/92 @1840	<0.2	1.9	81.6	<0.5	<0.2	<1	15.37	11.78	86.9

Note: "-t" = Total Recoverable "-d" = Dissolved

# FRENCH GULCH CHEMISTRY DATA: SEPTEMBER 22, 1992

Sampling Station	Sample Collection Date & Time	pH su	Alk. mg/l	Hardness mg/l	Ag-t µg/l	Ag-d µg/l	Zn-t µg/l	Zn-d µg/l	Al-t µg/l	Al-d µg/l
FG-0	9/22/92 @1345	6.79	29.43	47.3	<1	<1	12	<8	<50	<50
FG-1	9/22/92 @1320	6.87	36.54	52.9	<1	<1	19	10	<50	<50
FG-2	9/22/92 @1305	6.91	36.54	54.6	<1	<1	28	15	<50	<50
FG-3	9/22/92 @1245	6.89	44.66	61.5	<1	<1	26	13	<50	<50
FG-4	9/22/92 @1225	6.93	43.64	60.6	<1	<1	34	14	<50	<50
FG-5	9/22/92 @1200	6.83	40.60	62.4	<1	<1	115	84	<50	<50
FG-6A	9/22/92 @1130	6.03	8.12	440	1.7	2.9	43360	41260	71	<50
FG-7	9/22/92 @1110	6.54	44.66	102	<1	<1	3000	2827	<50	<50
FG-8	9/22/92 @1040	6.69	43.64	94.5	<1	<1	1547	1516	<50	<50
FG-9	9/22/92 @1612	7.91	40.63	103	<1	<1	1923	1830	63	<50
BR-1	9/22/92 @1550	8.36	53.79	65.7	<1	<1	34	11	108	<50
BR-2	9/22/92 @1520	7.98	38.57	102	<1	<1	1993	1887	<50	<50
BR-4	9/22/92 @1250	8.30	53.79	73.0	<1	<1	74	53	<50	<50
BR-5	9/22/92 @1200	8.32	51.76	71.8	<1	<1	44	31	<50	<50
SR-1	9/22/92 @1350	7.71	43.64	60.5	<1	<1	22	13	66	<50
BLANK 1	9/22/92 @1840	-----	-----	0.00	-----	<1	-----	<8	-----	<50
BLANK 2	9/22/92 @1840	-----	-----	0.00	-----	<1	-----	<8	-----	<50
BLANK 3	9/22/92 @1840	-----	-----	0.02	-----	<1	-----	<8	-----	<50
RECON	9/22/92 @1840	-----	55.82	86.9	-----	<1	-----	<8	-----	<50

Note: "-t" = Total Recoverable "-d" = Dissolved

# FRENCH GULCH CHEMISTRY DATA: SEPTEMBER 22, 1992

Sampling Station	Sample Collection Date & Time	pH su	Alk. mg/l	Hardness mg/l	Ni-t µg/l	Ni-d µg/l	Na-d mg/l
FG-0	9/22/92 @1345	6.79	29.43	47.3	<30	<30	<3
FG-1	9/22/92 @1320	6.87	36.54	52.9	<30	<30	<3
FG-2	9/22/92 @1305	6.91	36.54	54.6	<30	<30	<3
FG-3	9/22/92 @1245	6.89	44.66	61.5	<30	<30	<3
FG-4	9/22/92 @1225	6.93	43.64	60.6	<30	<30	<3
FG-5	9/22/92 @1200	6.83	40.60	62.4	<30	<30	<3
FG-6A	9/22/92 @1130	6.03	8.12	440	61	38	26.1
FG-7	9/22/92 @1110	6.54	44.66	102	<30	<30	<3
FG-8	9/22/92 @1040	6.69	43.64	94.5	<30	<30	<3
FG-9	9/22/92 @1612	7.91	40.63	103	<30	<30	<3
BR-1	9/22/92 @1550	8.36	53.79	65.7	<30	<30	<3
BR-2	9/22/92 @1520	7.98	38.57	102	<30	<30	<3
BR-4	9/22/92 @1250	8.30	53.79	73.0	<30	<30	<3
BR-5	9/22/92 @1200	8.32	51.76	71.8	<30	<30	<3
SR-1	9/22/92 @1350	7.71	43.64	60.5	<30	<30	<3
BLANK 1	9/22/92 @1840	-----	-----	0.00	-----	<30	<3
BLANK 2	9/22/92 @1840	-----	-----	0.00	-----	<30	<3
BLANK 3	9/22/92 @1840	-----	-----	0.02	-----	<30	<3
RECON	9/22/92 @1840	-----	55.82	86.9	-----	<30	22.6

Note: "-t" = Total Recoverable "-d" = Dissolved

# FRENCH GULCH CHEMISTRY DATA: SEPTEMBER 22, 1992

Sampling Station	Sample Collection Date & Time	pH su	Alk. mg/l	Hardness mg/l	Fe-t µg/l	Fe-d µg/l	Pb-t µg/l	Pb-d µg/l	Mn-t µg/l	Mn-d µg/l
FG-0	9/22/92 @1345	6.79	29.43	47.3	22	<10	<3	<3	3	<2
FG-1	9/22/92 @1320	6.87	36.54	52.9	54	33	<3	<3	13	12
FG-2	9/22/92 @1305	6.91	36.54	54.6	81	28	<3	<3	15	11
FG-3	9/22/92 @1245	6.89	44.66	61.5	33	14	3.7	<3	7	4
FG-4	9/22/92 @1225	6.93	43.64	60.6	78	13	3.3	<3	8	3
FG-5	9/22/92 @1200	6.83	40.60	62.4	52	<10	<3	<3	12	2
FG-6A	9/22/92 @1130	6.03	8.12	440	41080	38540	56.7	3.6	15690	15720
FG-7	9/22/92 @1110	6.54	44.66	102	302	27	<3	<3	699	698
FG-8	9/22/92 @1040	6.69	43.64	94.5	113	30	<3	<3	218	224
FG-9	9/22/92 @1612	7.91	40.63	103	164	<10	7.8	<3	355	361
BR-1	9/22/92 @1550	8.36	53.79	65.7	235	30	3.7	<3	17	5
BR-2	9/22/92 @1520	7.98	38.57	102	164	<10	5.5	<3	365	368
BR-4	9/22/92 @1250	8.30	53.79	73.0	45	<10	3.6	<3	6	3
BR-5	9/22/92 @1200	8.32	51.76	71.8	46	<10	3.8	<3	5	3
SR-1	9/22/92 @1350	7.71	43.64	60.5	60	<10	<3	<3	6	3
BLANK 1	9/22/92 @1840	-----	-----	0.00	-----	<10	-----	<3	-----	<2
BLANK 2	9/22/92 @1840	-----	-----	0.00	-----	<10	-----	<3	-----	<2
BLANK 3	9/22/92 @1840	-----	-----	0.02	-----	<10	-----	<3	-----	<2
RECON	9/22/92 @1840	-----	55.82	86.9	-----	<10	-----	<3	-----	<2

Note: "-t" = Total Recoverable "-d" = Dissolved

# FRENCH GULCH METALS DATA – October 21, 1993

Sampling Station	Sample Collection Date & Time	Field Measurements				pH su	Ca mg/l	Mg mg/l	Hardness mg/l	Na-d mg/l	K-d mg/l
		Flow ml/min	Temp °C	Temp for Conductivity	Cond umhos/cm						
FG-5	10/21/93 @1608	-----	5.4	21.6	131	7.99	23.29	1.87	65.9	1.36	<1
FG-6A	10/21/93 @1543	-----	8.0	21.1	1150	6.73	182.5	54.27	679	6.08	2.2
FG-7	10/21/93 @1436	-----	7.8	21.5	236	7.92	40.29	5.36	123	1.81	<1
FG-8	10/21/93 @1421	-----	7.1	21.2	209	7.31	36.50	4.39	109	1.81	1.0
FG-9	10/21/93 @1351	-----	4.9	21.4	236	7.80	39.45	5.42	121	2.01	<1
BR-1	10/21/93 @1330	-----	3.9	21.3	131	7.98	20.56	4.66	70.5	1.82	1.3
BR-2	10/21/93 @1155	-----	3.2	20.9	236	7.85	39.63	5.41	121	2.02	<1
BR-3	10/21/93 @1045	-----	7.6	6.2	100	8.18	22.98	4.47	75.8	2.63	<1

Sampling Station	Sample Collection Date & Time	pH su	Hardness mg/l	Cd-t ug/l	Cd-d ug/l	Cr-t ug/l	Cr-d ug/l	Cu-t ug/l	Cu-d ug/l	Ag-t ug/l	Ag-d ug/l
FG-5	10/21/93 @1608	7.99	65.9	<0.5	<0.5	<6	<6	<1	<1	<0.3	<0.3
FG-6A	10/21/93 @1543	6.73	679	25.6	24.0	<6	<6	6.0	6.0	<0.3	<0.3
FG-7	10/21/93 @1436	7.92	123	7.9	7.4	<6	<6	<1	<1	<0.3	<0.3
FG-7 Duplicate	10/21/93 @1436	7.92	-----	7.5	-----	<6	-----	<1	-----	<0.3	-----
FG-8	10/21/93 @1421	7.31	109	3.0	7.5	<6	<6	<1	<1	<0.3	<0.3
FG-9	10/21/93 @1351	7.80	121	6.8	6.6	<6	<6	<1	<1	<0.3	<0.3
BR-1	10/21/93 @1330	7.98	70.5	<0.5	<0.5	<6	<6	<1	<1	<0.3	<0.3
BR-2	10/21/93 @1155	7.85	121	6.9	6.7	<6	<6	<1	1.0	<0.3	<0.3
BR-3	10/21/93 @1045	8.18	75.8	<0.5	<0.5	<6	<6	<1	<1	<0.3	<0.3

NOTE: "-t" = Total Recoverable    "-d" = Dissolved

# **FRENCH GULCH METALS DATA – October 21, 1993**

Sampling Station	Sample Collection Date & Time	pH su	Hardness mg/l	Zn-t ug/l	Zn-d ug/l	Al-t ug/l	Al-d ug/l	Fe-t ug/l	Fe-d ug/l	Pb-t ug/l	Pb-d ug/l
FG-5	10/21/93 @1608	7.99	65.9	67	27	<40	<40	83	15	1.0	<1
FG-6A	10/21/93 @1543	6.73	679	69000	69550	250	<40	62091	62570	72.1	3.3
FG-7	10/21/93 @1436	7.92	123	3193	3254	<40	<40	282	10	1.9	<1
FG-7 Duplicate	10/21/93 @1436	7.92	-----	3020	-----	<40	-----	266	-----	1.7	-----
FG-8	10/21/93 @1421	7.31	109	749	792	<40	<40	43	21	<1	9.0
FG-9	10/21/93 @1351	7.80	121	2605	2872	<40	<40	105	14	9.0	1.4
BR-1	10/21/93 @1330	7.98	70.5	29	22	<40	<40	65	18	<1	<1
BR-2	10/21/93 @1155	7.85	121	2821	3077	<40	<40	119	14	9.7	1.8
BR-3	10/21/93 @1045	8.18	75.8	83	71	121	<40	148	22	3.2	<1

Sampling Station	Sample Collection Date & Time	pH su	Hardness mg/l	Mn-t ug/l	Mn-d ug/l	Ni-t ug/l	Ni-d ug/l
FG-5	10/21/93 @1608	7.99	65.9	17	3.0	<15	<15
FG-6A	10/21/93 @1543	6.73	679	24900	26040	75	69
FG-7	10/21/93 @1436	7.92	123	729	767	<15	<15
FG-7 Duplicate	10/21/93 @1436	7.92	-----	687	-----	<15	-----
FG-8	10/21/93 @1421	7.31	109	83	88	<15	<15
FG-9	10/21/93 @1351	7.80	121	413	460	<15	<15
BR-1	10/21/93 @1330	7.98	70.5	4.0	2.0	<15	<15
BR-2	10/21/93 @1155	7.85	121	452	496	<15	<15
BR-3	10/21/93 @1045	8.18	75.8	10	3.0	<15	<15

NOTE: "-t" = Total Recoverable    "-d" = Dissolved



# FRENCH GULCH QA/QC DATA – October 21, 1993

Sampling Station	Sample Collection Date & Time	Description	Ca mg/l	Mg mg/l	Hardness mg/l	Na-d mg/l	K-d mg/l
QC-1	11/21/93 @1615	Container Blank	0.01	<0.05	0.025	<0.05	<1
QC-2	11/21/93 @1615	Filter Blank	0.01	<0.05	0.025	<0.05	<1
QC-3	11/21/93 @1615	HNO <sub>3</sub> Blank	<0.01	<0.05	-----	<0.05	<1

Sampling Station	Sample Collection Date & Time	Description	Cd-d ug/l	Cr-d ug/l	Cu-d ug/l	Ag-d ug/l	Zn-d ug/l
QC-1	11/21/93 @1615	Container Blank	<0.5	<6	<1	<0.3	<4
QC-2	11/21/93 @1615	Filter Blank	<0.5	<6	<1	<0.3	<4
QC-3	11/21/93 @1615	HNO <sub>3</sub> Blank	<0.5	<6	<1	<0.3	<4

Sampling Station	Sample Collection Date & Time	Description	Al-d ug/l	Fe-d ug/l	Pb-d ug/l	Mn-d ug/l	Ni-d ug/l
QC-1	11/21/93 @1615	Container Blank	<40	<5	<1	<1	<15
QC-2	11/21/93 @1615	Filter Blank	<40	<5	<1	<1	<15
QC-3	11/21/93 @1615	HNO <sub>3</sub> Blank	<40	<5	<1	<1	<15

# **FRENCH GULCH CHEMISTRY DATA: November 16-17, 1993**

Sampling Station	Sample Collection Date & Time	pH su	Alk. mg/l	Hardness mg/l	Pb-t ug/l	Pb-d ug/l	Mn-t ug/l	Mn-d ug/l	Ni-t ug/l	Ni-d ug/l
<b>FG-5</b>	11/16/93 @1610	7.88	49	65.5	<1	<1	18	22	<15	<15
<b>FG-6A</b>	11/16/93 @1527	6.67	5.0	625	73.0	6.0	24080	23500	-----	69
<b>FG-7</b>	11/16/93 @1435	7.80	45	120	2.6	<1	852	860	<15	<15
<b>FG-7 Replica</b>	11/16/93 @1435	7.80	-----	-----	2.4	-----	845	-----	<15	-----
<b>FG-8</b>	11/16/93 @1420	7.29	43	109	<1	<1	141	143	<15	<15
<b>FG-9</b>	11/16/93 @1305	7.75	41	125	8.3	1.6	538	524	<15	<15
<b>BR-1</b>	11/16/93 @1244	7.84	57	67.0	1.0	<1	8.0	2.0	<15	<15
<b>BR-2</b>	11/16/93 @1119	7.71	39	126	10.4	1.9	366	<1	<15	<15
<b>BR-3</b>	11/16/93 @1025	8.13	51	74.6	2.2	<1	10	<1	<15	<15

NOTE: "-t" = Total Recoverable    "-d" = Dissolved

# **FRENCH GULCH CHEMISTRY DATA: November 16-17, 1993**

Sampling Station	Sample Collection Date & Time	pH su	Alk. mg/l	Hardness mg/l	Zn-t ug/l	Zn-d ug/l	Al-t ug/l	Al-d ug/l	Fe-t ug/l	Fe-d ug/l
<b>FG-5</b>	11/16/93 @1610	7.88	49	65.5	80	109	<40	<40	62	37
<b>FG-6A</b>	11/16/93 @1527	6.67	5.0	625	64930	60400	-----	<40	60620	58400
<b>FG-7</b>	11/16/93 @1435	7.80	45	120	4183	4198	<40	<40	296	56
<b>FG-7 Replica</b>	11/16/93 @1435	7.80	-----	-----	4109	-----	<40	-----	256	-----
<b>FG-8</b>	11/16/93 @1420	7.29	43	109	1453	1479	<40	<40	27	<5
<b>FG-9</b>	11/16/93 @1305	7.75	41	125	3411	3337	<40	<40	171	<5
<b>BR-1</b>	11/16/93 @1244	7.84	57	67.0	35	23	97	<40	147	11
<b>BR-2</b>	11/16/93 @1119	7.71	39	126	2931	2946	<40	<40	127	34
<b>BR-3</b>	11/16/93 @1025	8.13	51	74.6	83	60	84	<40	248	127

NOTE: "-t" = Total Recoverable    "-d" = Dissolved

# **FRENCH GULCH CHEMISTRY DATA: November 16-17, 1993**

Sampling Station	Sample Collection Date & Time	pH su	Alk. mg/l	Hardness mg/l	Cr-t ug/l	Cr-d ug/l	Cu-t ug/l	Cu-d ug/l	Ag-t ug/l	Ag-d ug/l
<b>FG-5</b>	11/16/93 @1610	7.88	49	65.5	<6	<6	1.9	<1	<0.3	<0.3
<b>FG-6A</b>	11/16/93 @1527	6.67	5.0	625	-----	<6	4.2	<6	<0.3	<0.3
<b>FG-7</b>	11/16/93 @1435	7.80	45	120	<6	<6	<1	<1	<0.3	<0.3
<b>FG-7 Replica</b>	11/16/93 @1435	7.80	-----	-----	<6	-----	1.4	-----	0.3	-----
<b>FG-8</b>	11/16/93 @1420	7.29	43	109	<6	<6	<1	<1	<0.3	<0.3
<b>FG-9</b>	11/16/93 @1305	7.75	41	125	<6	<6	1.6	<1	<0.3	<0.3
<b>BR-1</b>	11/16/93 @1244	7.84	57	67.0	<6	<6	1.1	<1	<0.3	<0.3
<b>BR-2</b>	11/16/93 @1119	7.71	39	126	<6	<6	<1	<1	<0.3	<0.3
<b>BR-3</b>	11/16/93 @1025	8.13	51	74.6	<6	<6	1.7	<1	<0.3	<0.3

NOTE: "-t" = Total Recoverable    "-d" = Dissolved

# **FRENCH GULCH CHEMISTRY DATA: November 16-17, 1993**

Sampling Station	Sample Collection Date & Time	pH su	Alk. mg/l	Ca mg/l	Mg mg/l	Hardness mg/l	Na-d mg/l	K-d mg/l	Cd-t ug/l	Cd-d ug/l
<b>FG-5</b>	11/16/93 @1610	7.88	49	22.98	1.962	65.5	1.40	<1	<0.5	<0.5
<b>FG-6A</b>	11/16/93 @1527	6.67	5.0	168.1	49.76	625	5.89	2.1	25.0	21.6
<b>FG-7</b>	11/16/93 @1435	7.80	45	38.62	5.674	120	1.75	<1	9.7	9.5
<b>FG-7 Replica</b>	11/16/93 @1435	7.80	-----	-----	-----	-----	-----	-----	9.7	-----
<b>FG-8</b>	11/16/93 @1420	7.29	43	36.22	4.622	109	1.69	<1	4.6	4.6
<b>FG-9</b>	11/16/93 @1305	7.75	41	39.87	6.110	125	2.02	<1	8.4	7.4
<b>BR-1</b>	11/16/93 @1244	7.84	57	19.22	4.606	67.0	2.03	<1	0.6	<0.5
<b>BR-2</b>	11/16/93 @1119	7.71	39	40.03	6.352	126	2.31	<1	7.2	6.8
<b>BR-3</b>	11/16/93 @1025	8.13	51	22.07	4.739	74.6	2.60	<1	0.6	<0.5

NOTE: "-t" = Total Recoverable    "-d" = Dissolved

# **FRENCH GULCH CHEMISTRY DATA: November 16-17, 1993**

Sampling Station	Sample Collection Date & Time	----- Field Measurements -----								
		Flow cfs	Temp °C	Cond us/cm/cm	pH su	Alk mg/l	TSS mg/l	F mg/l	Cl mg/l	SO <sub>4</sub> mg/l
<b>FG-5</b>	11/16/93 @1610	----	0.5	75.8	7.88	49	<4	<0.2	<0.5	18.8
<b>FG-6A</b>	11/16/93 @1527	----	0.7	780	6.67	5.0	28	1.23	2.30	842
<b>FG-7</b>	11/16/93 @1435	----	0.3	139	7.80	45	<4	<0.2	1.57	76.2
<b>FG-7 Replica</b>	11/16/93 @1435	----	0.3	139	7.80	----	----	----	----	----
<b>FG-8</b>	11/16/93 @1420	----	2.2	134	7.29	43	<4	<0.2	1.66	69.0
<b>FG-9</b>	11/16/93 @1305	----	1.3	150	7.75	41	<4	<0.2	1.96	87.0
<b>BR-1</b>	11/16/93 @1244	----	0.6	74.5	7.84	57	<4	<0.2	3.05	11.5
<b>BR-2</b>	11/16/93 @1119	----	2.4	144	7.71	39	<4	<0.2	2.19	87.0
<b>BR-3</b>	11/16/93 @1025	----	5.0	94.0	8.13	51	<4	<0.2	4.44	18.1

NOTE: "-t" = Total Recoverable    "-d" = Dissolved

# FRENCH GULCH QA/QC DATA – November 16–17, 1993

Sampling Station	Sample Collection Date & Time	Description	Ca mg/l	Mg mg/l	Hardness mg/l	Na-d mg/l	K-d mg/l
QC-1	11/16/93 @1625	Container Blank	<0.01	<0.05	0.0	<0.05	<1
QC-2	11/16/93 @1625	Filter Blank	<0.01	<0.05	0.0	<0.05	<1
QC-3	11/16/93 @1625	HNO <sub>3</sub> Blank	<0.01	<0.05	0.0	<0.05	<1

Sampling Station	Sample Collection Date & Time	Description	Cd-d ug/l	Cr-d ug/l	Cu-d ug/l	Ag-d ug/l	Zn-d ug/l
QC-1	11/16/93 @1625	Container Blank	<0.5	<6	<1	<0.3	<4
QC-2	11/16/93 @1625	Filter Blank	<0.5	<6	<1	<0.3	<4
QC-3	11/16/93 @1625	HNO <sub>3</sub> Blank	<0.5	<6	<1	<0.3	<4

Sampling Station	Sample Collection Date & Time	Description	Al-d ug/l	Fe-d ug/l	Pb-d ug/l	Mn-d ug/l	Ni-d ug/l
QC-1	11/16/93 @1625	Container Blank	<40	<5	<1	<1	<15
QC-2	11/16/93 @1625	Filter Blank	<40	<5	<1	<1	<15
QC-3	11/16/93 @1625	HNO <sub>3</sub> Blank	<40	<5	<1	<1	<15

NOTE: "-d" = Dissolved

# FRENCH GULCH QA/QC DATA – October 21, 1993

Sampling Station	Sample Collection Date & Time	Description	Ca mg/l	Mg mg/l	Hardness mg/l	Na-d mg/l	K-d mg/l
QC-1	11/21/93 @1615	Container Blank	0.01	<0.05	0.025	<0.05	<1
QC-2	11/21/93 @1615	Filter Blank	0.01	<0.05	0.025	<0.05	<1
QC-3	11/21/93 @1615	HNO <sub>3</sub> Blank	<0.01	<0.05	-----	<0.05	<1

Sampling Station	Sample Collection Date & Time	Description	Cd-d ug/l	Cr-d ug/l	Cu-d ug/l	Ag-d ug/l	Zn-d ug/l
QC-1	11/21/93 @1615	Container Blank	<0.5	<6	<1	<0.3	<4
QC-2	11/21/93 @1615	Filter Blank	<0.5	<6	<1	<0.3	<4
QC-3	11/21/93 @1615	HNO <sub>3</sub> Blank	<0.5	<6	<1	<0.3	<4

Sampling Station	Sample Collection Date & Time	Description	Al-d ug/l	Fe-d ug/l	Pb-d ug/l	Mn-d ug/l	Ni-d ug/l
QC-1	11/21/93 @1615	Container Blank	<40	<5	<1	<1	<15
QC-2	11/21/93 @1615	Filter Blank	<40	<5	<1	<1	<15
QC-3	11/21/93 @1615	HNO <sub>3</sub> Blank	<40	<5	<1	<1	<15



# **FRENCH GULCH CHEMISTRY DATA - August 22-24, 1994**

Sampling Station	Sample Collection Date & Time	pH su	Alk. mg/l	Hardness mg/l	Zn-t ug/l	Zn-d ug/l	Al-t ug/l	Al-d ug/l	Fe-t ug/l	Fe-d ug/l
KDS	8/23/94 @1250	6.56	66.3	222	5385	4051	449	42.0	3913	191
FG-5	8/23/94 @1650	8.60	45.5	53.9	70.0	37.0	<30	<30	151	17.0
FG-5 Replic	8/23/94 @1650	-----	-----	-----	-----	-----	-----	-----	98.0	-----
FG-6A	8/23/94 @1510	7.46	1.93	699	56852	63029	194	<30	60374	63998
FG-6B	8/23/94 @1545	7.73	* 0	1362	152000	173000	51.0	59.0	239547	276000
FG-7	8/23/94 @1242	7.86	47.2	92.9	2300	2127	<30	<30	225	22.0
FG-8	8/23/94 @1340	7.36	43.1	96.6	974	941	<30	<30	96.0	16.0
FG-9A	8/23/94 @0955	7.89	49.1	96.0	2300	2304	<30	<30	75.0	26.0
FG-9	8/23/94 @0905	7.94	45.7	102	2170	2199	32.0	<30	113	23.0
BR-1	8/23/94 @0835	8.14	54.5	61.2	17.0	7.00	68.0	<30	150	45.0
BR-2	8/22/94 @1745	8.20	49.3	76.1	630	590	82.0	<30	190	32.0
BR-3	8/22/94 @1605	8.10	53.4	69.5	75.0	70.0	36.0	<30	32.0	<5

NOTES: "-t" = Total Recoverable  
 \* pH < 4.5; Alkalinity = 0

"-d" = Dissolved

# **FRENCH GULCH CHEMISTRY DATA - August 22-24, 1994**

Sampling Station	Sample Collection Date & Time	pH su	Alk. mg/l	Hardness mg/l	Cr-t ug/l	Cr-d ug/l	Cu-t ug/l	Cu-d ug/l	Ag-t ug/l	Ag-d ug/l
KDS	8/23/94 @1250	6.56	66.3	222	<5	6.00	5.70	<1	0.300	<0.3
FG-5	8/23/94 @1650	8.60	45.5	53.9	<5	<5	<1	<1	<0.3	<0.3
FG-5 Replic	8/23/94 @1650	---	---	---	---	---	---	---	<0.3	---
FG-6A	8/23/94 @1510	7.46	1.93	699	<5	<5	<1	<1	<0.3	<0.3
FG-6B	8/23/94 @1545	7.73	* 0	1362	<5	<5	<1	<1	<0.3	<0.3
FG-7	8/23/94 @1242	7.86	47.2	92.9	<5	<5	1.30	<1	<0.3	<0.3
FG-8	8/23/94 @1340	7.36	43.1	96.6	<5	<5	<1	1.10	<0.3	<0.3
FG-9A	8/23/94 @0955	7.89	49.1	96.0	<5	<5	1.30	1.10	<0.3	<0.3
FG-9	8/23/94 @0905	7.94	45.7	102	<5	<5	1.80	1.00	<0.3	<0.3
BR-1	8/23/94 @0835	8.14	54.5	61.2	<5	<5	<1	2.10	<0.3	<0.3
BR-2	8/22/94 @1745	8.20	49.3	76.1	<5	<5	<1	<1	<0.3	<0.3
BR-3	8/22/94 @1605	8.10	53.4	69.5	<5	<5	1.60	1.40	<0.3	<0.3

NOTES: "-t" = Total Recoverable    "-d" = Dissolved  
 \* pH < 4.5; Alkalinity = 0

Sampling Station	Sample Collection Date & Time	pH su	Alk mg/l	Ca mg/l	Mg mg/l	Hardness mg/l	Na-d mg/l	K-d mg/l	Cd-t ug/l	Cd-d ug/l
KDS	8/23/94 @1250	6.56	66.3	54.7	20.8	222	7.67	2.20	6.10	2.00
FG-5	8/23/94 @1650	8.60	45.5	19.1	1.50	53.9	1.23	<1	<0.5	<0.5
FG-5 Replic	8/23/94 @1650	-----	-----	-----	-----	-----	-----	-----	<0.5	-----
FG-6A	8/23/94 @1510	7.46	1.93	190	54.5	699	6.79	2.10	22.2	20.0
FG-6B	8/23/94 @1545	7.73	* 0	358	114	1362	11.8	3.70	60.9	60.1
FG-7	8/23/94 @1242	7.86	47.2	30.8	3.87	92.9	1.70	<1	5.30	5.20
FG-8	8/23/94 @1340	7.36	43.1	31.9	4.12	96.6	1.91	1.10	3.40	3.20
FG-9A	8/23/94 @0955	7.89	49.1	31.6	4.15	96.0	1.80	1.10	6.30	5.70
FG-9	8/23/94 @0905	7.94	45.7	33.1	4.60	102	2.06	<1	6.10	5.40
BR-1	8/23/94 @0835	8.14	54.5	17.4	4.33	61.2	1.72	<1	<0.5	<0.5
BR-2	8/22/94 @1745	8.20	49.3	23.2	4.40	76.1	1.83	<1	2.50	1.70
BR-3	8/22/94 @1605	8.10	53.4	21.0	4.17	69.5	2.52	1.10	0.700	0.500

NOTES: "-t" = Total Recoverable      "-d" = Dissolved  
 \* pH < 4.5; Alkalinity = 0

# **FRENCH GULCH CHEMISTRY DATA - August 22-24, 1994**

Sampling Station	Sample Collection Date & Time	----- Field Measurements -----			pH su	Alk mg/l	TSS mg/l	F mg/l	Cl mg/l	SO <sub>4</sub> mg/l
		Flow cfs	Temp °C	Cond umhos/cm						
<b>KDS</b>	8/23/94 @1250	----	13.0	400	6.56	66.3	----	0.500	1.40	210
<b>FG-5</b>	8/23/94 @1650	2.17	12.2	93	8.60	45.5	----	<0.2	1.13	16.2
<b>FG-6A</b>	8/23/94 @1510	0.161	13.3	1043	7.46	1.93	----	<0.2	1.78	921
<b>FG-6B</b>	8/23/94 @1545	0.090	10.9	1912	7.73	* 0	----	<0.2	2.25	2130
<b>FG-7</b>	8/23/94 @1242	4.49	12.0	150	7.86	47.2	----	<0.2	1.25	51.3
<b>FG-8</b>	8/23/94 @1340	0.647	11.6	145	7.36	43.1	----	<0.2	1.23	58.2
<b>FG-9A</b>	8/23/94 @0955	5.69	9.6	137	7.89	49.1	----	<0.2	1.26	50.7
<b>FG-9</b>	8/23/94 @0905	5.53	8.1	137	7.94	45.7	----	<0.2	1.41	56.2
<b>BR-1</b>	8/23/94 @0835	6.81	10.9	86.6	8.14	54.5	----	<0.2	2.07	5.80
<b>BR-2</b>	8/22/94 @1745	15.9	14.3	125	8.20	49.3	----	<0.2	1.82	23.4
<b>BR-3</b>	8/22/94 @1605	50.6	12.1	111	8.10	53.4	----	<0.2	3.18	13.0

NOTES: "-t" = Total Recoverable    "-d" = Dissolved  
 \* pH < 4.5; Alkalinity = 0

# **FRENCH GULCH CHEMISTRY DATA - August 22-24, 1994**

Sampling Station	Sample Collection Date & Time	pH su	Alk. mg/l	Hardness mg/l	Pb-t ug/l	Pb-d ug/l	Mn-t ug/l	Mn-d ug/l	Ni-t ug/l	Ni-d ug/l
KDS	8/23/94 @1250	6.56	66.3	222	24.6	<1	6225	5345	21.0	<12
FG-5	8/23/94 @1650	8.60	45.5	53.9	3.40	<1	31.0	13.0	<12	<12
FG-5 Replic	8/23/94 @1650	-----	-----	-----	3.10	-----	10.0	-----	<12	-----
FG-6A	8/23/94 @1510	7.46	1.93	699	85.2	<1	23955	25670	66.0	62.0
FG-6B	8/23/94 @1545	7.73	* 0	1362	226	77.7	57160	56470	179	169
FG-7	8/23/94 @1242	7.86	47.2	92.9	3.20	<1	565	495	<12	<12
FG-8	8/23/94 @1340	7.36	43.1	96.6	1.60	<1	117	100	<12	<12
FG-9A	8/23/94 @0955	7.89	49.1	96.0	2.70	<1	498	515	<12	<12
FG-9	8/23/94 @0905	7.94	45.7	102	8.60	3.30	342	361	<12	<12
BR-1	8/23/94 @0835	8.14	54.5	61.2	1.30	<1	13.0	6.00	<12	<12
BR-2	8/22/94 @1745	8.20	49.3	76.1	4.80	1.40	120	115	<12	<12
BR-3	8/22/94 @1605	8.10	53.4	69.5	1.20	<1	3.00	2.00	<12	<12

NOTES: "-t" = Total Recoverable      "-d" = Dissolved  
 \* pH < 4.5; Alkalinity = 0

# FRENCH GULCH CHEMISTRY DATA: June 10–12, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk. mg/l	Hardness mg/l	Mn-t µg/l	Mn-d µg/l	Ni-t µg/l	Ni-d µg/l	As-t µg/l	As-d µg/l
FG-1	6/12/96 @1200	7.74	28.9	37.2	19.1	21.1	<10	<10	1.3	<0.8
FG-3	6/12/96 @1005	7.58	31.7	38.5	17.1	2.5	<10	<10	<0.8	<0.8
FG-5	6/11/96 @1623	7.50	30.7	37.4	57.3	5.9	<10	<10	1.9	<0.8
WP-1	6/12/96 @1200	2.94	<5	4980	1276690	1136130	1675	1377	95.5	39.2
KDS	6/13/96 @1200	5.78	37.1	296	13984.0	14960.0	38.3	40.9	<0.8	<0.8
FG-6C	6/11/96 @1520	6.05	41.6	2020	142437	150617	371.5	364.7	7.6	7.5
FG-6B	6/11/96 @1430	6.43	-----	-----	46136.1	-----	121.2	-----	2.2	-----
FG-6D	6/11/96 @1445	6.99	-----	-----	2032.1	-----	<10	-----	<0.8	-----
FG-6	6/11/96 @1415	4.62	<5	1070	28201.9	27681.4	119.1	116.6	7.7	2.3
FG-6A	6/11/96 @1350	6.31	<5	722	29040.8	29589.3	87.0	88.9	2.0	<0.8
FG-7	6/11/96 @1200	7.62	32.7	67.6	733.9	711.4	<10	<10	1.3	<0.8
FG-8	6/11/96 @1120	7.55	32.7	55.1	100.4	93.9	<10	<10	<0.8	<0.8
FG-9A	6/11/96 @1030	7.45	32.2	65.1	600.5	567.8	<10	<10	<0.8	<0.8
FG-9A Replicate	6/11/96 @1030	-----	-----	-----	587.3	-----	<10	-----	<0.8	-----
1121	6/13/96 @1315	6.35	21.9	215	5682.9	5775.2	13.9	15.9	<0.8	<0.8
1140	6/13/96 @1335	3.98	<5	728	30124.9	31901.6	79.5	81.3	1.4	<0.8
FG-9 Day #1	6/10/96 @1638	7.55	30.1	65.0	312.0	284.4	<10	<10	<0.8	<0.8
FG-9 Day #2	6/11/96 @0956	7.74	-----	-----	311.9	-----	<10	-----	<0.8	-----
BR-1	6/10/96 @1605	7.92	47.9	54.1	22.8	8.7	<10	<10	<0.8	<0.8
BR-2	6/10/96 @1520	7.95	43.5	58.0	94.6	82.7	<10	<10	<0.8	<0.8
BR-3	6/10/96 @1420	7.94	41.5	54.2	66.8	25.5	<10	<10	<0.8	<0.8

NOTE: "-t" = Total Recoverable    "-d" = Dissolved

# FRENCH GULCH CHEMISTRY DATA: June 10-12, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk. mg/l	Hardness mg/l	Zn-t µg/l	Zn-d µg/l	Al-t µg/l	Al-d µg/l	Fe-t µg/l	Fe-d µg/l	Pb-t µg/l	Pb-d µg/l
FG-1	6/12/96 @1200	7.74	28.9	37.2	15.9	14.6	356	146	446.5	193.3	4.2	3.6
FG-3	6/12/96 @1005	7.58	31.7	38.5	13.2	10.4	248	<40	263.2	7.3	4.0	<0.8
FG-5	6/11/96 @1623	7.50	30.7	37.4	46.2	23.4	888	<40	953.1	19.1	17.0	<0.8
WP-1	6/12/96 @1200	2.94	<5	4980	3538000	3105000	114510	95854	837588	694200	5490.4	744.3
KDS	6/13/96 @1200	5.78	37.1	296	9839.4	10460	222	163	1795.4	1508.0	2.2	<0.8
FG-6C	6/11/96 @1520	6.05	41.6	2020	308100	298190	589	371	301040	299948	463.4	255.3
FG-6B	6/11/96 @1430	6.43	-----	-----	119870	-----	300	-----	106900	-----	182.9	-----
FG-6D	6/11/96 @1445	6.99	-----	-----	6514.9	-----	<40	-----	2689.0	-----	<0.8	-----
FG-6	6/11/96 @1415	4.62	<5	1070	131930	129150	3001	2241	171854	155972	187.2	65.4
FG-6A	6/11/96 @1350	6.31	<5	722	85914	86202	713	<40	82211.1	73377.2	102.1	1.3
FG-7	6/11/96 @1200	7.62	32.7	67.6	2673.5	2681.4	271	<40	749.2	166.0	19.5	4.1
FG-8	6/11/96 @1120	7.55	32.7	55.1	749.0	753.5	174	<40	277.3	50.8	8.4	0.9
FG-9A	6/11/96 @1030	7.45	32.2	65.1	2287.6	2239.1	249	<40	668.1	135.0	16.3	3.5
FG-9A Replicate	6/11/96 @1030	-----	-----	-----	2271.2	-----	240	-----	585.2	-----	13.8	-----
1121	6/13/96 @1315	6.35	21.9	215	17601	18183	94	<40	1088.1	519.5	9.9	<0.8
1140	6/13/96 @1335	3.98	<5	728	78892	83845	718	679	36358.3	34111.9	82.0	56.7
FG-9 Day #1	6/10/96 @1638	7.55	30.1	65.0	2096.8	2072.8	181	<40	366.3	83.5	11.8	4.1
FG-9 Day #2	6/11/96 @0956	7.74	-----	-----	2138.0	-----	132	-----	281.0	-----	10.4	-----
BR-1	6/10/96 @1605	7.92	47.9	54.1	18.6	12.4	398	<40	386.3	20.5	1.9	<0.8
BR-2	6/10/96 @1520	7.95	43.5	58.0	599.5	589.4	233	<40	275.0	37.9	4.1	<0.8
BR-3	6/10/96 @1420	7.94	41.5	54.2	268.8	242.7	1275	<40	1256.5	27.9	4.5	<0.8

NOTE: "-t" = Total Recoverable      "-d" = Dissolved

# FRENCH GULCH CHEMISTRY DATA: June 10-12, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk. mg/l	Hardness mg/l	Cd-t µg/l	Cd-d µg/l	Cr-t µg/l	Cr-d µg/l	Cu-t µg/l	Cu-d µg/l	Ag-t µg/l	Ag-d µg/l
FG-1	6/12/96 @1200	7.74	28.9	37.2	<0.5	<0.5	<4	<4	1.4	1.4	<0.2	<0.2
FG-3	6/12/96 @1005	7.58	31.7	38.5	<0.5	0.5	4.0	<4	<0.8	0.9	<0.2	<0.2
FG-5	6/11/96 @1623	7.50	30.7	37.4	<0.5	<0.5	<4	<4	6.0	1.8	<0.2	<0.2
WP-1	6/12/96 @1200	2.94	<5	4980	22500	19800	<40	<4	9575.2	8393.4	25.2	1.10
KDS	6/13/96 @1200	5.78	37.1	296	17.1	17.7	<4	<4	11.4	6.7	<0.2	<0.2
FG-6C	6/11/96 @1520	6.05	41.6	2020	372	381	<4	<4	8.9	6.7	<0.2	<0.2
FG-6B	6/11/96 @1430	6.43	-----	-----	94.5	-----	<4	-----	16.1	-----	<0.2	-----
FG-6D	6/11/96 @1445	6.99	-----	-----	7.8	-----	<4	-----	2.5	-----	<0.2	-----
FG-6	6/11/96 @1415	4.62	<5	1070	305	309	<4	<4	222.0	193	<0.2	<0.2
FG-6A	6/11/96 @1350	6.31	<5	722	100	102	<4	<4	49.2	20.5	<0.2	<0.2
FG-7	6/11/96 @1200	7.62	32.7	67.6	7.2	8.1	<4	<4	6.6	2.3	<0.2	<0.2
FG-8	6/11/96 @1120	7.55	32.7	55.1	3.7	2.8	<4	<4	5.0	1.6	<0.2	<0.2
FG-9A	6/11/96 @1030	7.45	32.2	65.1	6.9	7.1	<4	<4	3.3	2.1	<0.2	<0.2
FG-9A Replicate	6/11/96 @1030	-----	-----	-----	6.1	-----	<4	-----	3.1	-----	<0.2	-----
1121	6/13/96 @1315	6.35	21.9	215	36.2	37.6	<4	<4	8.5	5.0	0.20	<0.2
1140	6/13/96 @1335	3.98	<5	728	89.5	95.3	<4	<4	46.7	40.1	<0.2	<0.2
FG-9 Day #1	6/10/96 @1638	7.55	30.1	65.0	6.3	5.7	<4	<4	5.9	2.7	<0.2	<0.2
FG-9 Day #2	6/11/96 @0956	7.74	-----	-----	7.6	-----	<4	-----	5.7	-----	<0.2	-----
BR-1	6/10/96 @1605	7.92	47.9	54.1	<0.5	<0.5	<4	<4	5.7	1.3	<0.2	<0.2
BR-2	6/10/96 @1520	7.95	43.5	58.0	2.0	1.5	<4	<4	5.1	1.8	<0.2	<0.2
BR-3	6/10/96 @1420	7.94	41.5	54.2	0.9	0.9	<4	<4	4.6	2.4	<0.2	<0.2

NOTE: "-t" = Total Recoverable    "-d" = Dissolved



# FRENCH GULCH CHEMISTRY DATA: June 10-12, 1996

Sampling Station	Sample Collection Date & Time	F mg/l	Cl mg/l	SO <sub>4</sub> mg/l	Br mg/l	TOC mg/l	Hg-t µg/l	Ca-d mg/l	Mg-d mg/l	Hardness mg/l	Na-d mg/l	K-d mg/l
FG-1	6/12/96 @1200	<0.2	1.03	9.0	<0.5	2.1	<0.2	13.20	1.03	37.2	0.94	<1
FG-3	6/12/96 @1005	<0.2	1.05	9.1	<0.5	2.1	-----	13.59	1.11	38.5	0.95	<1
FG-5	6/11/96 @1623	<0.2	1.05	9.1	<0.5	2.1	-----	13.23	1.07	37.4	0.95	<1
WP-1	6/12/96 @1200	<0.2	2.02	17600	<0.5	8.3	0.40	394.8	968.9	4980	77.40	6.8
KDS	6/13/96 @1200	0.26	<0.5	317	<0.5	<1.5	-----	67.20	31.10	296	7.58	1.6
FG-6C	6/11/96 @1520	<0.2	8.07	4120	1.01	<1.5	<0.2	477.4	201.4	2020	12.93	4.1
FG-6B	6/11/96 @1430	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
FG-6D	6/11/96 @1445	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
FG-6	6/11/96 @1415	<0.2	2.08	2360	<0.5	<1.5	<0.2	269.8	95.59	1070	9.06	3.2
FG-6A	6/11/96 @1350	<0.2	2.16	1150	<0.5	<1.5	<0.2	184.0	63.84	722	5.87	2.0
FG-7	6/11/96 @1200	<0.2	1.21	35.8	<0.5	1.8	<0.2	21.75	3.23	67.6	1.26	<1
FG-8	6/11/96 @1120	<0.2	1.27	20.9	<0.5	1.5	-----	18.38	2.23	55.1	1.23	<1
FG-9A	6/11/96 @1030	<0.2	1.06	32.3	<0.5	1.9	-----	21.09	3.03	65.1	1.21	<1
FG-9A Replicate	6/11/96 @1030	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
1121	6/13/96 @1315	<0.2	1.51	215	<0.5	<1.5	-----	60.77	15.36	215	2.52	<1
1140	6/13/96 @1335	<0.2	2.11	1160	<0.5	<1.5	-----	190.6	61.22	728	5.92	2.2
FG-9 Day #1	6/10/96 @1638	<0.2	1.33	36.7	<0.5	1.9	-----	20.77	3.18	65.0	1.33	<1
FG-9 Day #2	6/11/96 @0956	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
BR-1	6/10/96 @1605	<0.2	1.81	6.4	<0.5	2.8	-----	15.91	3.50	54.1	1.36	<1
BR-2	6/10/96 @1520	<0.2	1.69	14.3	<0.5	2.4	-----	17.55	3.44	58.0	1.41	<1
BR-3	6/10/96 @1420	<0.2	2.28	12.7	<0.5	2.3	-----	16.09	3.41	54.2	1.84	<1

NOTE: "-t" = Total Recoverable      "-d" = Dissolved

# FRENCH GULCH CHEMISTRY DATA: June 10–12, 1996

Sampling Station	Sample Collection Date & Time	Flow cfs	Temp °C	Field Measurements		pH su	DO mg/l	Alk mg/l	TSS mg/l	NH <sub>3</sub> mg/l	NO <sub>2</sub> /NO <sub>3</sub> mg/l	PO <sub>4</sub> mg/l
				Cond $\mu$ mhos/cm	Cond $\mu$ siemens/cm							
FG-1	6/12/96 @1200	56.4	5.2	66.3	<sup>Δ</sup> 71.6	7.74	9.70	28.9	6	<0.05	0.08	0.03
FG-3	6/12/96 @1005	61.1	3.8	71.8	<sup>Δ</sup> 76.8	7.58	10.55	31.7	4	<0.05	0.07	0.02
FG-5	6/11/96 @1623	34.4	6.3	65.2	<sup>Δ</sup> 71.9	7.50	8.93	30.7	9	<0.05	0.06	0.03
WP-1	6/12/96 @1200	-----	6.8	10090	<sup>Δ</sup> 10905	2.94	-----	<5	210	0.65	0.81	0.36
KDS*	6/13/96 @1200	-----	6.8	531	616	5.78	1.7	37.1	<4	<0.05	<0.05	<0.02
FG-6C	6/11/96 @1520	0.062	7.4	3080	<sup>Δ</sup> 3405	6.05	3.66	41.6	40	0.30	<0.05	<0.02
FG-6B	6/11/96 @1430	0.427	8.2	-----	-----	6.43	7.38	-----	-----	-----	-----	-----
FG-6D	6/11/96 @1445	-----	3.8	-----	-----	6.99	-----	-----	-----	-----	-----	-----
FG-6	6/11/96 @1415	0.117	16.5	2100	<sup>Δ</sup> 2294	4.62	6.65	<5	37	0.09	<0.05	<0.02
FG-6A	6/11/96 @1350	0.544	12.8	1306	<sup>Δ</sup> 1447	6.31	7.21	<5	34	0.13	<0.05	<0.02
FG-7	6/11/96 @1200	49.9	5.2	124	<sup>Δ</sup> 135	7.62	9.46	32.7	5	<0.05	0.07	0.02
FG-8	6/11/96 @1120	15.1	4.8	99.4	<sup>Δ</sup> 108	7.55	9.72	32.7	<4	<0.05	0.07	0.02
FG-9A	6/11/96 @1030	69.7	5.0	-----	-----	7.45	10.1	32.2	<4	<0.05	<0.05	<0.02
FG-9A Replicate	6/11/96 @1030	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
1121*	6/13/96 @1315	-----	3.4	411	475	6.35	3.3	21.9	<4	<0.05	<0.05	<0.02
1140*	6/13/96 @1335	-----	4.0	1281	1452	3.98	2.82	<5	9	0.15	0.06	<0.02
FG-9 Day #1	6/10/96 @1638	73.0	6.6	128	<sup>Δ</sup> 138	7.55	8.13	30.1	<4	<0.05	0.08	<0.02
FG-9 Day #2	6/11/96 @0956	74.0	4.7	-----	-----	7.74	10.2	-----	-----	-----	-----	-----
BR-1	6/10/96 @1605	141	9.5	89.7	<sup>Δ</sup> 97.9	7.92	7.71	47.9	5	<0.05	0.06	<0.02
BR-2	6/10/96 @1520	240	10.6	99.7	<sup>Δ</sup> 109	7.95	7.80	43.5	6	<0.05	0.07	0.02
BR-3	6/10/96 @1420	381	10.6	103	<sup>Δ</sup> 110	7.94	-----	41.5	24	<0.05	0.08	0.03

\* Field measurements for these sites were taken by USGS.

Δ EPA conductivities were taken in the lab due to problems with the probe in the field. Conductivities were originally measured in  $\mu$ mhos/cm but were corrected to  $\mu$ siemens/cm using a YSI formula.

# **FRENCH GULCH CHEMISTRY DATA: June 10-12, 1996**

Sampling Station	Sample Collection Date & Time	pH su	Alk. mg/l	Hardness mg/l	Mn-t µg/l	Mn-d µg/l	Ni-t µg/l	Ni-d µg/l	As-t µg/l	As-d µg/l
FG-1	6/12/96 @1200	7.74	28.9	37.2	19.1	21.1	<10	<10	1.3	<0.8
FG-3	6/12/96 @1005	7.58	31.7	38.5	17.1	2.5	<10	<10	<0.8	<0.8
FG-5	6/11/96 @1623	7.50	30.7	37.4	57.3	5.9	<10	<10	1.9	<0.8
WP-1	6/12/96 @1200	2.94	<5	4980	1276690	1136130	1675	1377	95.5	39.2
KDS	6/13/96 @1200	5.78	37.1	296	13984.0	14960.0	38.3	40.9	<0.8	<0.8
FG-6C	6/11/96 @1520	6.05	41.6	2020	142437	150617	371.5	364.7	7.6	7.5
FG-6B	6/11/96 @1430	6.43	-----	-----	46136.1	-----	121.2	-----	2.2	-----
FG-6D	6/11/96 @1445	6.99	-----	-----	2032.1	-----	<10	-----	<0.8	-----
FG-6	6/11/96 @1415	4.62	<5	1070	28201.9	27681.4	119.1	116.6	7.7	2.3
FG-6A	6/11/96 @1350	6.31	<5	722	29040.8	29589.3	87.0	88.9	2.0	<0.8
FG-7	6/11/96 @1200	7.62	32.7	67.6	733.9	711.4	<10	<10	1.3	<0.8
FG-8	6/11/96 @1120	7.55	32.7	55.1	100.4	93.9	<10	<10	<0.8	<0.8
FG-9A	6/11/96 @1030	7.45	32.2	65.1	600.5	567.8	<10	<10	<0.8	<0.8
FG-9A Replicate	6/11/96 @1030	-----	-----	-----	587.3	-----	<10	-----	<0.8	-----
1121	6/13/96 @1315	6.35	21.9	215	5682.9	5775.2	13.9	15.9	<0.8	<0.8
1140	6/13/96 @1335	3.98	<5	728	30124.9	31901.6	79.5	81.3	1.4	<0.8
FG-9 Day #1	6/10/96 @1638	7.55	30.1	65.0	312.0	284.4	<10	<10	<0.8	<0.8
FG-9 Day #2	6/11/96 @0956	7.74	-----	-----	311.9	-----	<10	-----	<0.8	-----
BR-1	6/10/96 @1605	7.92	47.9	54.1	22.8	8.7	<10	<10	<0.8	<0.8
BR-2	6/10/96 @1520	7.95	43.5	58.0	94.6	82.7	<10	<10	<0.8	<0.8
BR-3	6/10/96 @1420	7.94	41.5	54.2	66.8	25.5	<10	<10	<0.8	<0.8

NOTE: "-t" = Total Recoverable      "-d" = Dissolved

# FRENCH GULCH CHEMISTRY DATA: June 10-12, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk. mg/l	Hardness mg/l	Zn-t µg/l	Zn-d µg/l	Al-t µg/l	Al-d µg/l	Fe-t µg/l	Fe-d µg/l	Pb-t µg/l	Pb-d µg/l
FG-1	6/12/96 @1200	7.74	28.9	37.2	15.9	14.6	356	146	446.5	193.3	4.2	3.6
FG-3	6/12/96 @1005	7.58	31.7	38.5	13.2	10.4	248	<40	263.2	7.3	4.0	<0.8
FG-5	6/11/96 @1623	7.50	30.7	37.4	46.2	23.4	888	<40	953.1	19.1	17.0	<0.8
WP-1	6/12/96 @1200	2.94	<5	4980	3538000	3105000	114510	95854	837588	694200	5490.4	744.3
KDS	6/13/96 @1200	5.78	37.1	296	9839.4	10460	222	163	1795.4	1508.0	2.2	<0.8
FG-6C	6/11/96 @1520	6.05	41.6	2020	308100	298190	589	371	301040	299948	463.4	255.3
FG-6B	6/11/96 @1430	6.43	-----	-----	119870	-----	300	-----	106900	-----	182.9	-----
FG-6D	6/11/96 @1445	6.99	-----	-----	6514.9	-----	<40	-----	2689.0	-----	<0.8	-----
FG-6	6/11/96 @1415	4.62	<5	1070	131930	129150	3001	2241	171854	155972	187.2	65.4
FG-6A	6/11/96 @1350	6.31	<5	722	85914	86202	713	<40	82211.1	73377.2	102.1	1.3
FG-7	6/11/96 @1200	7.62	32.7	67.6	2673.5	2681.4	271	<40	749.2	166.0	19.5	4.1
FG-8	6/11/96 @1120	7.55	32.7	55.1	749.0	753.5	174	<40	277.3	50.8	8.4	0.9
FG-9A	6/11/96 @1030	7.45	32.2	65.1	2287.6	2239.1	249	<40	668.1	135.0	16.3	3.5
FG-9A Replicate	6/11/96 @1030	-----	-----	-----	2271.2	-----	240	-----	585.2	-----	13.8	-----
1121	6/13/96 @1315	6.35	21.9	215	17601	18183	94	<40	1088.1	519.5	9.9	<0.8
1140	6/13/96 @1335	3.98	<5	728	78892	83845	718	679	36358.3	34111.9	82.0	56.7
FG-9 Day #1	6/10/96 @1638	7.55	30.1	65.0	2096.8	2072.8	181	<40	366.3	83.5	11.8	4.1
FG-9 Day #2	6/11/96 @0956	7.74	-----	-----	2138.0	-----	132	-----	281.0	-----	10.4	-----
BR-1	6/10/96 @1605	7.92	47.9	54.1	18.6	12.4	398	<40	386.3	20.5	1.9	<0.8
BR-2	6/10/96 @1520	7.95	43.5	58.0	599.5	589.4	233	<40	275.0	37.9	4.1	<0.8
BR-3	6/10/96 @1420	7.94	41.5	54.2	268.8	242.7	1275	<40	1256.5	27.9	4.5	<0.8

NOTE: "-t" = Total Recoverable    "-d" = Dissolved

# FRENCH GULCH CHEMISTRY DATA: June 10-12, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk. mg/l	Hardness mg/l	Cd-t µg/l	Cd-d µg/l	Cr-t µg/l	Cr-d µg/l	Cu-t µg/l	Cu-d µg/l	Ag-t µg/l	Ag-d µg/l
FG-1	6/12/96 @1200	7.74	28.9	37.2	<0.5	<0.5	<4	<4	1.4	1.4	<0.2	<0.2
FG-3	6/12/96 @1005	7.58	31.7	38.5	<0.5	0.5	4.0	<4	<0.8	0.9	<0.2	<0.2
FG-5	6/11/96 @1623	7.50	30.7	37.4	<0.5	<0.5	<4	<4	6.0	1.8	<0.2	<0.2
WP-1	6/12/96 @1200	2.94	<5	4980	22500	19800	<40	<4	9575.2	8393.4	25.2	1.10
KDS	6/13/96 @1200	5.78	37.1	296	17.1	17.7	<4	<4	11.4	6.7	<0.2	<0.2
FG-6C	6/11/96 @1520	6.05	41.6	2020	372	381	<4	<4	8.9	6.7	<0.2	<0.2
FG-6B	6/11/96 @1430	6.43	-----	-----	94.5	-----	<4	-----	16.1	-----	<0.2	-----
FG-6D	6/11/96 @1445	6.99	-----	-----	7.8	-----	<4	-----	2.5	-----	<0.2	-----
FG-6	6/11/96 @1415	4.62	<5	1070	305	309	<4	<4	222.0	193	<0.2	<0.2
FG-6A	6/11/96 @1350	6.31	<5	722	100	102	<4	<4	49.2	20.5	<0.2	<0.2
FG-7	6/11/96 @1200	7.62	32.7	67.6	7.2	8.1	<4	<4	6.6	2.3	<0.2	<0.2
FG-8	6/11/96 @1120	7.55	32.7	55.1	3.7	2.8	<4	<4	5.0	1.6	<0.2	<0.2
FG-9A	6/11/96 @1030	7.45	32.2	65.1	6.9	7.1	<4	<4	3.3	2.1	<0.2	<0.2
FG-9A Replicate	6/11/96 @1030	-----	-----	-----	6.1	-----	<4	-----	3.1	-----	<0.2	-----
1121	6/13/96 @1315	6.35	21.9	215	36.2	37.6	<4	<4	8.5	5.0	0.20	<0.2
1140	6/13/96 @1335	3.98	<5	728	89.5	95.3	<4	<4	46.7	40.1	<0.2	<0.2
FG-9 Day #1	6/10/96 @1638	7.55	30.1	65.0	6.3	5.7	<4	<4	5.9	2.7	<0.2	<0.2
FG-9 Day #2	6/11/96 @0956	7.74	-----	-----	7.6	-----	<4	-----	5.7	-----	<0.2	-----
BR-1	6/10/96 @1605	7.92	47.9	54.1	<0.5	<0.5	<4	<4	5.7	1.3	<0.2	<0.2
BR-2	6/10/96 @1520	7.95	43.5	58.0	2.0	1.5	<4	<4	5.1	1.8	<0.2	<0.2
BR-3	6/10/96 @1420	7.94	41.5	54.2	0.9	0.9	<4	<4	4.6	2.4	<0.2	<0.2

NOTE: "-t" = Total Recoverable      "-d" = Dissolved

# **FRENCH GULCH CHEMISTRY DATA: June 10-12, 1996**

Sampling Station	Sample Collection Date & Time	F mg/l	Cl mg/l	SO <sub>4</sub> mg/l	Br mg/l	TOC mg/l	Hg-t µg/l	Ca-d mg/l	Mg-d mg/l	Hardness mg/l	Na-d mg/l	K-d mg/l
FG-1	6/12/96 @1200	<0.2	1.03	9.0	<0.5	2.1	<0.2	13.20	1.03	37.2	0.94	<1
FG-3	6/12/96 @1005	<0.2	1.05	9.1	<0.5	2.1	-----	13.59	1.11	38.5	0.95	<1
FG-5	6/11/96 @1623	<0.2	1.05	9.1	<0.5	2.1	-----	13.23	1.07	37.4	0.95	<1
WP-1	6/12/96 @1200	<0.2	2.02	17600	<0.5	8.3	0.40	394.8	968.9	4980	77.40	6.8
KDS	6/13/96 @1200	0.26	<0.5	317	<0.5	<1.5	-----	67.20	31.10	296	7.58	1.6
FG-6C	6/11/96 @1520	<0.2	8.07	4120	1.01	<1.5	<0.2	477.4	201.4	2020	12.93	4.1
FG-6B	6/11/96 @1430	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
FG-6D	6/11/96 @1445	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
FG-6	6/11/96 @1415	<0.2	2.08	2360	<0.5	<1.5	<0.2	269.8	95.59	1070	9.06	3.2
FG-6A	6/11/96 @1350	<0.2	2.16	1150	<0.5	<1.5	<0.2	184.0	63.84	722	5.87	2.0
FG-7	6/11/96 @1200	<0.2	1.21	35.8	<0.5	1.8	<0.2	21.75	3.23	67.6	1.26	<1
FG-8	6/11/96 @1120	<0.2	1.27	20.9	<0.5	1.5	-----	18.38	2.23	55.1	1.23	<1
FG-9A	6/11/96 @1030	<0.2	1.06	32.3	<0.5	1.9	-----	21.09	3.03	65.1	1.21	<1
FG-9A Replicate	6/11/96 @1030	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
1121	6/13/96 @1315	<0.2	1.51	215	<0.5	<1.5	-----	60.77	15.36	215	2.52	<1
1140	6/13/96 @1335	<0.2	2.11	1160	<0.5	<1.5	-----	190.6	61.22	728	5.92	2.2
FG-9 Day #1	6/10/96 @1638	<0.2	1.33	36.7	<0.5	1.9	-----	20.77	3.18	65.0	1.33	<1
FG-9 Day #2	6/11/96 @0956	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
BR-1	6/10/96 @1605	<0.2	1.81	6.4	<0.5	2.8	-----	15.91	3.50	54.1	1.36	<1
BR-2	6/10/96 @1520	<0.2	1.69	14.3	<0.5	2.4	-----	17.55	3.44	58.0	1.41	<1
BR-3	6/10/96 @1420	<0.2	2.28	12.7	<0.5	2.3	-----	16.09	3.41	54.2	1.84	<1

NOTE: \*-t\* = Total Recoverable    \*-d\* = Dissolved

# FRENCH GULCH CHEMISTRY DATA: June 10-12, 1996

Sampling Station	Sample Collection Date & Time	Flow cfs	Temp °C	Field Measurements		pH su	DO mg/l	Alk mg/l	TSS mg/l	NH <sub>3</sub> mg/l	NO <sub>2</sub> /NO <sub>3</sub> mg/l	PO <sub>4</sub> mg/l
				Cond µmhos/cm	Cond µsiemens/cm							
FG-1	6/12/96 @1200	56.4	5.2	66.3	^ 71.6	7.74	9.70	28.9	6	<0.05	0.08	0.03
FG-3	6/12/96 @1005	61.1	3.8	71.8	^ 76.8	7.58	10.55	31.7	4	<0.05	0.07	0.02
FG-5	6/11/96 @1623	34.4	6.3	65.2	^ 71.9	7.50	8.93	30.7	9	<0.05	0.06	0.03
WP-1	6/12/96 @1200	-----	6.8	10090	^ 10905	2.94	-----	<5	210	0.65	0.81	0.36
KDS*	6/13/96 @1200	-----	6.8	531	616	5.78	1.7	37.1	<4	<0.05	<0.05	<0.02
FG-6C	6/11/96 @1520	0.062	7.4	3080	^ 3405	6.05	3.66	41.6	40	0.30	<0.05	<0.02
FG-6B	6/11/96 @1430	0.427	8.2	-----	-----	6.43	7.38	-----	-----	-----	-----	-----
FG-6D	6/11/96 @1445	-----	3.8	-----	-----	6.99	-----	-----	-----	-----	-----	-----
FG-6	6/11/96 @1415	0.117	16.5	2100	^ 2294	4.62	6.65	<5	37	0.09	<0.05	<0.02
FG-6A	6/11/96 @1350	0.544	12.8	1306	^ 1447	6.31	7.21	<5	34	0.13	<0.05	<0.02
FG-7	6/11/96 @1200	49.9	5.2	124	^ 135	7.62	9.46	32.7	5	<0.05	0.07	0.02
FG-8	6/11/96 @1120	15.1	4.8	99.4	^ 108	7.55	9.72	32.7	<4	<0.05	0.07	0.02
FG-9A	6/11/96 @1030	69.7	5.0	-----	-----	7.45	10.1	32.2	<4	<0.05	<0.05	<0.02
FG-9A Replicate	6/11/96 @1030	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
1121*	6/13/96 @1315	-----	3.4	411	475	6.35	3.3	21.9	<4	<0.05	<0.05	<0.02
1140*	6/13/96 @1335	-----	4.0	1281	1452	3.98	2.82	<5	9	0.15	0.06	<0.02
FG-9 Day #1	6/10/96 @1638	73.0	6.6	128	^ 138	7.55	8.13	30.1	<4	<0.05	0.08	<0.02
FG-9 Day #2	6/11/96 @0956	74.0	4.7	-----	-----	7.74	10.2	-----	-----	-----	-----	-----
BR-1	6/10/96 @1605	141	9.5	89.7	^ 97.9	7.92	7.71	47.9	5	<0.05	0.06	<0.02
BR-2	6/10/96 @1520	240	10.6	99.7	^ 109	7.95	7.80	43.5	6	<0.05	0.07	0.02
BR-3	6/10/96 @1420	381	10.6	103	^ 110	7.94	-----	41.5	24	<0.05	0.08	0.03

\* Field measurements for these sites were taken by USGS.

Δ EPA conductivities were taken in the lab due to problems with the probe in the field. Conductivities were originally measured in µmhos/cm but were corrected to µsiemens/cm using a YSI formula.

# FRENCH GULCH BACKGROUND WATER CHEMISTRY DATA: July 22-23, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk mg/l	Hardness mg/l	Fe-t µg/l	Fe-d µg/l	Pb-t µg/l	Pb-d µg/l	Mn-t µg/l	Mn-d µg/l
FG-1	7/22/96 @1850	7.87	32.9	40.6	40.7	14.0	<0.8	<0.8	4.8	6.0
FG-3	7/22/96 @1750	8.04	38.3	46.4	35.0	<5	<0.8	<0.8	5.0	3.6
FG-5	7/22/96 @1655	8.01	38.6	46.1	26.3	18.1	<0.8	<0.8	2.8	6.8
CBMA-1	7/23/96 @1435	7.47	124	224	1095.7	526.9	1.9	<0.8	892.3	862.4
FG-6C	7/22/96 @1620	6.32	14.0	1720	355400	339140	397.47	59.0	98609.0	100857
FG-6B	7/22/96 @1550	6.47	5.40	1230	174250	163200	230.39	12.8	60213.8	60635.5
FG-6D	7/22/96 @1605	6.62	-----	-----	8250.7	-----	<0.8	-----	6806.0	-----
FG-6A	7/22/96 @1525	6.24	<5	908	109870	95411	144.68	1.1	42337.3	41105.8
FG-7	7/22/96 @1445	7.67	39.6	96.2	283.7	96.8	6.5	0.9	1165.6	1119.1
FG-8	7/22/96 @1405	7.74	38.3	63.6	118.6	5.6	3.7	<0.8	19.7	15.8
FG-9A	7/22/96 @1330	7.87	39.4	84.7	153.4	28.6	4.2	<0.8	804.9	777.8
1121	7/23/96 @1525	6.70	24.0	446	417.1	117.1	45.76	23.7	17213.7	17746.9
MGB-1	7/23/96 @1353	7.66	33.5	81.5	297.3	<5	4.7	<0.8	8.5	1.4
RLCVT-1	7/23/96 @1345	7.50	33.9	86.1	46.5	<5	1.4	<0.8	11.7	7.2
FG-9	7/22/96 @1230	7.75	34.5	83.7	38.4	38.2	5.6	3.4	32.5	30.7
FG-9 Day #2	7/23/96 @1255	7.52	-----	-----	44.0	-----	5.5	-----	31.1	-----
BR-1	7/23/96 @1215	8.12	37.9	41.7	150.7	20.6	1.2	<0.8	18.7	6.1
BR-2	7/23/96 @1140	8.24	36.8	48.8	133.7	20.2	1.1	<0.8	20.9	9.7
BR-3	7/23/96 @1000	8.02	39.9	50.1	194.4	6.8	<0.8	<0.8	9.8	3.2
SR-1	7/23/96 @1100	7.93	39.7	49.9	72.6	6.3	<0.8	<0.8	7.6	4.4
SR-1 Replicate	7/23/96 @1100	-----	-----	-----	67.2	-----	<0.8	-----	7.4	-----
BR-5	7/23/96 @0915	8.01	41.6	52.3	116.3	<5	<0.8	<0.8	7.6	3.7
BR-5 Replicate	7/23/96 @0915	-----	-----	51.5	-----	<5	-----	<0.8	-----	3.4

NOTE: "-t" = Total Recoverable      "-d" = Dissolved



# **FRENCH GULCH BACKGROUND WATER CHEMISTRY DATA: July 22-23, 1996**

Sampling Station	Sample Collection Date & Time	pH su	Alk mg/l	Hardness mg/l	Ni-t µg/l	Ni-d µg/l	As-t µg/l	As-d µg/l
FG-1	7/22/96 @1850	7.87	32.9	40.6	<10	<10	<1	<1
FG-3	7/22/96 @1750	8.04	38.3	46.4	<10	<10	<1	1.20
FG-5	7/22/96 @1655	8.01	38.6	46.1	<10	<10	1.20	<1
CBMA-1	7/23/96 @1435	7.47	124	224	<10	<10	<1	1.30
FG-6C	7/22/96 @1620	6.32	14.0	1720	283.4	281.7	4.70	4.20
FG-6B	7/22/96 @1550	6.47	5.40	1230	161.6	170.2	<1	<1
FG-6D	7/22/96 @1605	6.62	-----	-----	17.8	-----	<1	-----
FG-6A	7/22/96 @1525	6.24	<5	908	112.9	115.1	3.20	<1
FG-7	7/22/96 @1445	7.67	39.6	96.2	<10	<10	<1	<1
FG-8	7/22/96 @1405	7.74	38.3	63.6	<10	<10	<1	1.00
FG-9A	7/22/96 @1330	7.87	39.4	84.7	<10	<10	<1	<1
1121	7/23/96 @1525	6.70	24.0	446	43.0	57.5	<1	<1
MGB-1	7/23/96 @1353	7.66	33.5	81.5	<10	<10	<1	1.00
RLCVT-1	7/23/96 @1345	7.50	33.9	86.1	<10	<10	<1	<1
FG-9	7/22/96 @1230	7.75	34.5	83.7	<10	<10	<1	<1
FG-9 Day #2	7/23/96 @1255	7.52	-----	-----	<10	-----	<1	-----
BR-1	7/23/96 @1215	8.12	37.9	41.7	<10	<10	<1	<1
BR-2	7/23/96 @1140	8.24	36.8	48.8	<10	<10	<1	1.10
BR-3	7/23/96 @1000	8.02	39.9	50.1	<10	<10	<1	<1
SR-1	7/23/96 @1100	7.93	39.7	49.9	<10	<10	<1	<1
SR-1 Replicate	7/23/96 @1100	-----	-----	-----	<10	-----	<1	-----
BR-5	7/23/96 @0915	8.01	41.6	52.3	<10	<10	<1	<1
BR-5 Replicate	7/23/96 @0915	-----	-----	51.5	-----	<10	-----	<1

NOTE: "-t" = Total Recoverable      "-d" = Dissolved

# FRENCH GULCH BACKGROUND WATER CHEMISTRY DATA: July 22-23, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk mg/l	Hardness mg/l	Ag-t µg/l	Ag-d µg/l	Zn-t µg/l	Zn-d µg/l	Al-t µg/l	Al-d µg/l
FG-1	7/22/96 @1850	7.87	32.9	40.6	<0.2	<0.2	7.0	19.6	<40	<40
FG-3	7/22/96 @1750	8.04	38.3	46.4	<0.2	<0.2	8.4	15.6	43	<40
FG-5	7/22/96 @1655	8.01	38.6	46.1	<0.2	<0.2	14.6	32.6	<40	<40
CBMA-1	7/23/96 @1435	7.47	124	224	<0.2	<0.2	3000.4	2796.0	<40	<40
FG-6C	7/22/96 @1620	6.32	14.0	1720	<0.2	<0.2	255690	244820	306	118
FG-6B	7/22/96 @1550	6.47	5.40	1230	<0.2	<0.2	154020	149000	317	<40
FG-6D	7/22/96 @1605	6.62	-----	-----	<0.2	-----	18772	-----	<40	-----
FG-6A	7/22/96 @1525	6.24	<5	908	<0.2	<0.2	107700	102530	255	46
FG-7	7/22/96 @1445	7.67	39.6	96.2	<0.2	<0.2	4618.3	4483.6	<40	156
FG-8	7/22/96 @1405	7.74	38.3	63.6	<0.2	<0.2	681.3	658.7	55	55
FG-9A	7/22/96 @1330	7.87	39.4	84.7	<0.2	<0.2	3381.1	3304.1	<40	<40
1121	7/23/96 @1525	6.70	24.0	446	<0.2	<0.2	50549	50447	59	81
MGB-1	7/23/96 @1353	7.66	33.5	81.5	<0.2	<0.2	1616.8	1536.6	194	<40
RLCVT-1	7/23/96 @1345	7.50	33.9	86.1	<0.2	<0.2	2083.4	2012.2	<40	<40
FG-9	7/22/96 @1230	7.75	34.5	83.7	<0.2	<0.2	2270.1	2216.4	<40	80
FG-9 Day #2	7/23/96 @1255	7.52	-----	-----	<0.2	-----	2293.6	-----	<40	-----
BR-1	7/23/96 @1215	8.12	37.9	41.7	<0.2	<0.2	8.8	8.8	76	<40
BR-2	7/23/96 @1140	8.24	36.8	48.8	<0.2	<0.2	415.1	376.7	63	<40
BR-3	7/23/96 @1000	8.02	39.9	50.1	<0.2	<0.2	147.7	131.2	344	<40
SR-1	7/23/96 @1100	7.93	39.7	49.9	<0.2	<0.2	10.0	7.2	72	<40
SR-1 Replicate	7/23/96 @1100	-----	-----	-----	<0.2	-----	8.2	-----	55	-----
BR-5	7/23/96 @0915	8.01	41.6	52.3	<0.2	<0.2	113.6	98.7	121	<40
BR-5 Replicate	7/23/96 @0915	-----	-----	51.5	-----	<0.2	-----	99.0	-----	<40

NOTE: "-t" = Total Recoverable      "-d" = Dissolved

# FRENCH GULCH BACKGROUND WATER CHEMISTRY DATA: July 22-23, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk mg/l	Hardness mg/l	Cd-t µg/l	Cd-d µg/l	Cr-t µg/l	Cr-d µg/l	Cu-t µg/l	Cu-d µg/l
FG-1	7/22/96 @1850	7.87	32.9	40.6	<0.5	<0.5	<4	<4	<0.8	1.5
FG-3	7/22/96 @1750	8.04	38.3	46.4	<0.5	<0.5	<4	<4	<0.8	<0.8
FG-5	7/22/96 @1655	8.01	38.6	46.1	<0.5	<0.5	<4	<4	<0.8	<0.8
CBMA-1	7/23/96 @1435	7.47	124	224	2.9	2.0	<4	<4	<0.8	<0.8
FG-6C	7/22/96 @1620	6.32	14.0	1720	284	281	<4	<4	12.8	8.0
FG-6B	7/22/96 @1550	6.47	5.40	1230	114	114	<4	<4	10.9	4.2
FG-6D	7/22/96 @1605	6.62	-----	-----	10.4	-----	<4	-----	1.3	-----
FG-6A	7/22/96 @1525	6.24	<5	908	72.5	71.0	<4	<4	5.2	2.3
FG-7	7/22/96 @1445	7.67	39.6	96.2	10.6	11.9	<4	<4	1.0	<0.8
FG-8	7/22/96 @1405	7.74	38.3	63.6	3.2	3.0	<4	<4	1.1	<0.8
FG-9A	7/22/96 @1330	7.87	39.4	84.7	7.6	8.9	<4	<4	1.8	<0.8
1121	7/23/96 @1525	6.70	24.0	446	136	136	<4	<4	16.7	15.3
MGB-1	7/23/96 @1353	7.66	33.5	81.5	6.1	5.4	<4	<4	0.8	<0.8
RLCVT-1	7/23/96 @1345	7.50	33.9	86.1	6.2	5.5	<4	<4	<0.8	<0.8
FG-9	7/22/96 @1230	7.75	34.5	83.7	4.5	5.6	<4	6.2	<0.8	<0.8
FG-9 Day #2	7/23/96 @1255	7.52	-----	-----	7.6	-----	4.4	-----	<0.8	-----
BR-1	7/23/96 @1215	8.12	37.9	41.7	<0.5	<0.5	<4	<4	<0.8	<0.8
BR-2	7/23/96 @1140	8.24	36.8	48.8	1.3	1.1	<4	<4	<0.8	<0.8
BR-3	7/23/96 @1000	8.02	39.9	50.1	0.9	0.5	<4	<4	<0.8	<0.8
SR-1	7/23/96 @1100	7.93	39.7	49.9	<0.5	<0.5	<4	<4	<0.8	<0.8
SR-1 Replicate	7/23/96 @1100	-----	-----	-----	<0.5	-----	<4	-----	<0.8	-----
BR-5	7/23/96 @0915	8.01	41.6	52.3	1.0	<0.5	<4	<4	<0.8	<0.8
BR-5 Replicate	7/23/96 @0915	-----	-----	51.5	-----	0.7	-----	<4	-----	<0.8

NOTE: "-t" = Total Recoverable    "-d" = Dissolved

# **FRENCH GULCH BACKGROUND WATER CHEMISTRY DATA: July 22-23, 1996**

Sampling Station	Sample Collection Date & Time	Field Measurements				Alk mg/l	TSS mg/l	F mg/l	Cl mg/l	SO <sub>4</sub> mg/l	Br mg/l
		Flow cfs	Temp °C	Cond µmhos/cm	pH su						
FG-1	7/22/96 @1850	9.41	12.7	67.5	7.87	32.9	<4	<0.2	1.21	12.8	<0.5
FG-3	7/22/96 @1750	9.71	11.8	77.3	8.04	38.3	<4	<0.2	1.31	11.7	<0.5
FG-5	7/22/96 @1655	3.29	12.5	82.3	8.01	38.6	<4	<0.2	1.29	13.2	<0.5
CBMA-1	7/23/96 @1435	0.316	5.5	315	7.47	124	<4	0.29	1.56	100	<0.5
FG-6C	7/22/96 @1620	* 0.067	11.5	2770	6.32	14.0	77	<0.2	3.87	2690	1.98
FG-6B	7/22/96 @1550	0.226	14.3	2090	6.47	5.40	48	<0.2	2.72	1660	<0.5
FG-6D	7/22/96 @1605	* 0.006	6.9	425	6.62	-----	-----	-----	-----	-----	-----
FG-6A	7/22/96 @1525	0.207	17.3	1722	6.24	<5	31	<0.2	2.51	1160	<0.5
FG-7	7/22/96 @1445	11.6	10.7	166	7.67	39.6	<4	<0.2	1.43	59.7	<0.5
FG-8	7/22/96 @1405	3.73	9.3	105	7.74	38.3	<4	<0.2	1.40	25.7	<0.5
FG-9A	7/22/96 @1330	14.9	10.6	147	7.87	39.4	<4	0.20	1.49	47.9	<0.5
1121	7/23/96 @1525	-----	5.1	653	6.70	24.0	<4	0.33	2.19	466	<0.5
MGB-1	7/23/96 @1353	* 0.017	10.6	146	7.66	33.5	<4	0.20	1.67	47.7	<0.5
RLCVT-1	7/23/96 @1345	* 1.75	7.0	145	7.50	33.9	<4	<0.2	1.61	50.7	<0.5
FG-9	7/22/96 @1230	13.9	9.3	142	7.75	34.5	<4	<0.2	1.58	50.2	<0.5
FG-9 Day #2	7/23/96 @1255	12.7	8.6	143	7.52	-----	-----	-----	-----	-----	-----
BR-1	7/23/96 @1215	65.4	13.1	70.2	8.12	37.9	<4	0.21	1.82	6.9	<0.5
BR-2	7/23/96 @1140	78.8	12.0	83.7	8.24	36.8	<4	0.21	1.79	13.5	<0.5
BR-3	7/23/96 @1000	121	10.4	87.2	8.02	39.9	<4	0.20	2.56	12.3	<0.5
SR-1	7/23/96 @1100	28.5	9.7	83.6	7.93	39.7	<4	<0.2	1.65	12.7	<0.5
SR-1 Replicate	7/23/96 @1100	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
BR-5	7/23/96 @0915	175	11.1	85.2	8.01	41.6	<4	0.20	2.56	13.2	<0.5
BR-5 Replicate	7/23/96 @0915	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

\* Flow for these stations was estimated onsite.

# **FRENCH GULCH QA/QC DATA: July 23, 1996**

Sampling Station	Sample Collection Date & Time	Description	TOC mg/l	NH <sub>3</sub> mg/l	NO <sub>2</sub> /NO <sub>3</sub> mg/l	PO <sub>4</sub> mg/l	As-t µg/l	Cd-t µg/l	Cu-t µg/l	Pb-t µg/l	Ag-t µg/l	Al-t µg/l
QC-1	7/23/96 @1015	Container Blank	----	----	----	----	<1	<0.5	<0.8	<0.8	<0.2	<40
QC-2	7/23/96 @1015	Filter Blank	----	----	----	----	<1	<0.5	<0.8	<0.8	<0.2	<40
QC-3	7/23/96 @1015	HNO <sub>3</sub> Blank	----	----	----	----	<1	<0.5	<0.8	<0.8	<0.2	56
QC-4	7/23/96 @1015	H <sub>2</sub> SO <sub>4</sub> Blank	<1.5	<0.05	<0.05	<0.02	----	----	----	----	----	----

# **FRENCH GULCH QA/QC DATA: July 23, 1996**

Sampling Station	Sample Collection Date & Time	Description	Cr-t µg/l	Fe-t µg/l	Mn-t µg/l	Ni-t µg/l	Zn-t µg/l
QC-1	7/23/96 @1015	Container Blank	<4	5.5	<1	<10	4.3
QC-2	7/23/96 @1015	Filter Blank	<4	<5	<1	<10	<4
QC-3	7/23/96 @1015	HNO <sub>3</sub> Blank	<4	13.0	<1	<10	<4
QC-4	7/23/96 @1015	H <sub>2</sub> SO <sub>4</sub> Blank	----	----	----	----	----

NOTE: "-t" = Total Recoverable

# **FRENCH GULCH CHEMISTRY DATA: November 16-17, 1993**

Sampling Station	Sample Collection Date & Time	----- Field Measurements -----								
		Flow cfs	Temp oC	Cond us/cm	pH su	Alk mg/l	TSS mg/l	F mg/l	Cl mg/l	SO4 mg/l
<b>MW-1</b>	11/17/93 @1146	----	7.8	1630	6.79	78	38	3.10	2.45	1750
<b>MW-2</b>	11/17/93 @1045	----	5.7	1630	7.58	82	154	3.03	2.58	1710
<b>MW-3</b>	11/17/93 @1116	----	7.6	1530	6.64	21	32	1.92	2.40	1750
<b>MW-4</b>	11/17/93 @1215	----	8.3	1600	6.47	82	28	2.96	2.54	1640
<b>MW-5</b>	11/17/93 @1248	----	8.3	1680	6.43	102	18	3.02	2.34	1870
<b>MW-6</b>	11/17/93 @1005	----	7.0	1519	7.00	114	44	2.86	2.41	1580
<b>MW-7</b>	11/17/93 @0930	----	3.6	567	6.89	43	17	0.96	1.69	460
<b>MW-8 L</b>	11/17/93 @1312	----	7.9	1680	6.73	76	30	3.06	2.49	1850
<b>MW-8 U</b>	11/17/93 @1341	----	8.8	2150	6.18	0.0	326	4.30	3.67	2610
<b>MW-8 U Replica</b>	11/17/93 @1341	----	8.8	2150	6.18	-----	-----	-----	-----	-----
<b>MW-9</b>	11/16/93 @1525	----	4.0	89.6	7.51	51	5.0	<0.2	<0.5	20.6
<b>MW-11</b>	11/16/93 @1341	----	5.4	122	6.95	45	13	<0.2	1.55	45.7
<b>MW-12</b>	11/16/93 @1308	----	5.6	164	7.75	82	410	<0.2	3.29	54.8
<b>MW-13</b>	11/16/93 @1445	----	7.0	3090	6.00	23	1354	5.95	7.49	4190
<b>MW-14</b>	11/16/93 @1130	----	5.7	732	7.34	108	5.0	0.99	15.3	560

# **FRENCH GULCH CHEMISTRY DATA: November 16-17, 1993**

Sampling Station	Sample Collection Date & Time	pH su	Alk. mg/l	Ca mg/l	Mg mg/l	Hardness mg/l	Na-d mg/l	K-d mg/l	Cd-t ug/l	Cd-d ug/l
<b>MW-1</b>	11/17/93 @1146	6.79	78	388	119.4	1460	14.04	2.9	54.6	50.2
<b>MW-2</b>	11/17/93 @1045	7.58	82	448	97.28	1519	11.86	3.0	2.9	<0.5
<b>MW-3</b>	11/17/93 @1116	6.64	21	311	97.64	1178	10.36	2.2	26.0	18.3
<b>MW-4</b>	11/17/93 @1215	6.47	82	381	113.4	1418	14.16	3.3	36.2	32.6
<b>MW-5</b>	11/17/93 @1248	6.43	102	401	118.3	1488	14.72	3.4	61.3	55.8
<b>MW-6</b>	11/17/93 @1005	7.00	114	434	110.0	1536	13.93	3.7	6.3	3.8
<b>MW-7</b>	11/17/93 @0930	6.89	43	134	31.66	465	3.93	1.5	1.1	<0.5
<b>MW-8 L</b>	11/17/93 @1312	6.73	76	378	123.6	1453	13.20	2.8	197	140
<b>MW-8 U</b>	11/17/93 @1341	6.18	0.0	378	135.1	1500	13.02	2.3	484	450
<b>MW-8 U Replica</b>	11/17/93 @1341	6.18	-----	-----	-----	-----	-----	-----	489	-----
<b>MW-9</b>	11/16/93 @1525	7.51	51	24.63	1.955	69.5	1.31	<1	1.8	<0.5
<b>MW-11</b>	11/16/93 @1341	6.95	45	29.43	3.647	88.5	2.06	1.1	28.4	25.5
<b>MW-12</b>	11/16/93 @1308	7.75	82	38.38	5.651	119	5.19	5.1	11.3	1.3
<b>MW-13</b>	11/16/93 @1445	6.00	23	393.8	228.1	1922	23.97	10.8	3650	3430
<b>MW-14</b>	11/16/93 @1130	7.34	108	215.2	34.02	677	22.25	3.1	<0.5	0.9

NOTE: "-t" = Total Recoverable    "-d" = Dissolved

# **FRENCH GULCH CHEMISTRY DATA: November 16-17, 1993**

Sampling Station	Sample Collection Date & Time	pH su	Alk. mg/l	Hardness mg/l	Cr-t ug/l	Cr-d ug/l	Cu-t ug/l	Cu-d ug/l	Ag-t ug/l	Ag-d ug/l
<b>MW-1</b>	11/17/93 @1146	6.79	78	1460	----	----	12.7	<6	<0.3	<0.3
<b>MW-2</b>	11/17/93 @1045	7.58	82	1519	----	<6	1.6	<6	<0.3	<0.3
<b>MW-3</b>	11/17/93 @1116	6.64	21	1178	----	<6	0.6	<6	<0.3	<0.3
<b>MW-4</b>	11/17/93 @1215	6.47	82	1418	----	----	2.5	<6	<0.3	<0.3
<b>MW-5</b>	11/17/93 @1248	6.43	102	1488	----	----	3.5	<6	<0.3	<0.3
<b>MW-6</b>	11/17/93 @1005	7.00	114	1536	----	<6	1.3	<6	<0.3	<0.3
<b>MW-7</b>	11/17/93 @0930	6.89	43	465	<6	<6	1.8	<6	<0.3	<0.3
<b>MW-8 L</b>	11/17/93 @1312	6.73	76	1453	----	----	2.2	<6	<0.3	<0.3
<b>MW-8 U</b>	11/17/93 @1341	6.18	0.0	1500	----	----	137	14	1.0	<0.3
<b>MW-8 U Replica</b>	11/17/93 @1341	6.18	----	----	----	----	160	----	1.5	----
<b>MW-9</b>	11/16/93 @1525	7.51	51	69.5	<6	<6	2.8	<1	<0.3	<0.3
<b>MW-11</b>	11/16/93 @1341	6.95	45	88.5	<6	<6	6.4	<1	<0.3	<0.3
<b>MW-12</b>	11/16/93 @1308	7.75	82	119	<6	<6	34.4	3.7	<0.3	<0.3
<b>MW-13</b>	11/16/93 @1445	6.00	23	1922	----	15	154	<1	0.7	<0.3
<b>MW-14</b>	11/16/93 @1130	7.34	108	677	<6	<6	2.1	1.9	<0.3	<0.3

NOTE: "-t" = Total Recoverable    "-d" = Dissolved



# FRENCH GULCH CHEMISTRY DATA: November 16-17, 1993

Sampling Station	Sample Collection Date & Time	pH su	Alk. mg/l	Hardness mg/l	Zn-t ug/l	Zn-d ug/l	Al-t ug/l	Al-d ug/l	Fe-t ug/l	Fe-d ug/l
MW-1	11/17/93 @1146	6.79	78	1460	125300	131900	-----	49	94910	108840
MW-2	11/17/93 @1045	7.58	82	1519	73380	76600	-----	<40	157800	174380
MW-3	11/17/93 @1116	6.64	21	1178	133100	140480	-----	55	246100	243400
MW-4	11/17/93 @1215	6.47	82	1418	121900	123720	-----	<40	80110	82540
MW-5	11/17/93 @1248	6.43	102	1488	127900	123260	-----	58	99360	97380
MW-6	11/17/93 @1005	7.00	114	1536	47980	48240	-----	<40	56700	62460
MW-7	11/17/93 @0930	6.89	43	465	21360	21680	<40	<40	50440	50620
MW-8 L	11/17/93 @1312	6.73	76	1453	190900	186480	-----	48	105500	104000
MW-8 U	11/17/93 @1341	6.18	0.0	1500	262900	25200	39800	175	541800	429000
MW-8 U Replica	11/17/93 @1341	6.18	-----	-----	260400	-----	44300	-----	570700	-----
MW-9	11/16/93 @1525	7.51	51	69.5	129	121	110	<40	436	<5
MW-11	11/16/93 @1341	6.95	45	88.5	2977	2930	308	<40	276	<5
MW-12	11/16/93 @1308	7.75	82	119	2082	114	10250	<40	18490	<5
MW-13	11/16/93 @1445	6.00	23	1922	1448000	1495000	-----	127	46200	20470
MW-14	11/16/93 @1130	7.34	108	677	64	73	185	<40	391	116

NOTE: "-t" = Total Recoverable "-d" = Dissolved

# **FRENCH GULCH CHEMISTRY DATA: November 16-17, 1993**

Sampling Station	Sample Collection Date & Time	pH su	Alk. mg/l	Hardness mg/l	Pb-t ug/l	Pb-d ug/l	Mn-t ug/l	Mn-d ug/l	Ni-t ug/l	Ni-d ug/l
<b>MW-1</b>	11/17/93 @1146	6.79	78	1460	290	297	33120	34360	----	140
<b>MW-2</b>	11/17/93 @1045	7.58	82	1519	2.5	<1	28990	30240	----	130
<b>MW-3</b>	11/17/93 @1116	6.64	21	1178	139	99.5	41160	42600	----	119
<b>MW-4</b>	11/17/93 @1215	6.47	82	1418	33.2	23.3	31960	31900	----	165
<b>MW-5</b>	11/17/93 @1248	6.43	102	1488	20.9	13.4	35990	34000	----	124
<b>MW-6</b>	11/17/93 @1005	7.00	114	1536	15.6	7.1	21670	21480	----	131
<b>MW-7</b>	11/17/93 @0930	6.89	43	465	3.3	<1	15600	15360	<15	<15
<b>MW-8 L</b>	11/17/93 @1312	6.73	76	1453	66.1	30.7	45250	43620	----	132
<b>MW-8 U</b>	11/17/93 @1341	6.18	0.0	1500	1107	20.2	51940	50420	----	167
<b>MW-8 U Replica</b>	11/17/93 @1341	6.18	----	----	1352	----	51040	----	----	----
<b>MW-9</b>	11/16/93 @1525	7.51	51	69.5	6.1	<1	32	8.0	<15	<15
<b>MW-11</b>	11/16/93 @1341	6.95	45	88.5	36.7	3.8	78	59	<15	<15
<b>MW-12</b>	11/16/93 @1308	7.75	82	119	47.4	<1	1531	112	<15	<15
<b>MW-13</b>	11/16/93 @1445	6.00	23	1922	685.0	302	130200	130060	1078	910
<b>MW-14</b>	11/16/93 @1130	7.34	108	677	1.1	<1	493	342	<15	<15

NOTE: "-t" = Total Recoverable    "-d" = Dissolved

## FRENCH GULCH CHEMISTRY DATA - August 22-24, 1994

Sampling Station	Sample Collection Date & Time	----- Field Measurements -----				pH su	Alk mg/l	TSS mg/l	F mg/l	Cl mg/l	SO4 mg/l
		Flow cfs	Temp oC	Cond umhos/cm							
KDS	8/23/94 @1250	-----	13.0	400	6.56	66.3	-----	0.500	1.40	210	
MW-1	8/23/94 @1538	-----	10.3	1246	8.26	* 0	-----	0.280	1.74	1130	
MW-2	8/23/94 @1118	-----	9.2	2020	7.31	* 0	-----	<0.2	2.04	2140	
MW-3	8/23/94 @1150	-----	7.5	1820	6.53	* 0	-----	<0.2	2.14	2040	
MW-4	8/23/94 @1500	-----	8.5	1675	7.34	4.61	-----	<0.2	1.85	1750	
MW-5	8/23/94 @1620	-----	9.2	1616	7.61	16.2	-----	<0.2	1.80	1800	
MW-6U	8/23/94 @1045	-----	7.9	2110	6.40	* 0	-----	<0.2	2.27	2390	
MW-6L	8/23/94 @1020	-----	8.0	1732	6.78	62.7	-----	<0.2	1.98	1760	
MW-7U	8/23/94 @0920	-----	7.0	526	7.36	5.25	-----	<0.2	1.34	367	
MW-7L	8/23/94 @0845	-----	4.5	577	7.17	10.9	-----	<0.2	1.33	401	
MW-8U	8/23/94 @1240	-----	10.4	10100	4.19	* 0	-----	9.41	2.66	24200	
MW-8L	8/23/94 @1216	-----	8.5	1241	6.56	* 0	-----	<0.2	2.08	1910	
MW-9	8/23/94 @0955	-----	8.8	105	7.33	49.6	-----	<0.2	1.23	16.7	
MW-11	8/22/94 @1703	-----	6.2	134	7.22	49.1	-----	<0.2	1.96	40.3	
MW-12	8/23/94 @0830	-----	6.5	168	7.58	69.9	-----	<0.2	2.08	46.0	
MW-13	8/23/94 @1245	-----	7.6	3500	5.94	5.69	-----	0.350	4.27	5190	
MW-14	8/22/94 @1519	-----	8.0	1373	7.59	131	-----	<0.2	1.58	1120	

\* pH < 4.5; Alkalinity = 0

## FRENCH GULCH CHEMISTRY DATA - August 22-24, 1994

Sampling Station	Sample Collection Date & Time	pH su	Alk mg/l	Ca mg/l	Mg mg/l	Hardness mg/l	Na-d mg/l	K-d mg/l	Cd-t ug/l	Cd-d ug/l
<b>KDS</b>	8/23/94 @1250	6.56	66.3	54.7	20.8	222	7.67	2.20	6.10	2.00
<b>MW-1</b>	8/23/94 @1538	8.26	* 0	223	63.2	817	15.3	3.30	86.6	27.9
<b>MW-2</b>	8/23/94 @1118	7.31	* 0	500	115	1721	13.2	3.70	2.70	3.10
<b>MW-3</b>	8/23/94 @1150	6.53	* 0	319	104	1225	10.7	3.50	31.3	24.7
<b>MW-4</b>	8/23/94 @1500	7.34	4.61	351	110	1329	13.0	3.60	30.8	29.2
<b>MW-5</b>	8/23/94 @1620	7.61	16.2	341	107	1289	13.7	3.30	54.6	50.9
<b>MW-6U</b>	8/23/94 @1045	6.40	* 0	356	112	1349	13.0	3.70	85.0	86.9
<b>MW-6L</b>	8/23/94 @1020	6.78	62.7	417	104	1467	13.6	3.80	4.30	3.90
<b>MW-7U</b>	8/23/94 @0920	7.36	5.25	96.9	24.3	342	3.70	1.40	2.10	<0.5
<b>MW-7L</b>	8/23/94 @0845	7.17	10.9	112	26.9	391	4.08	1.60	<0.5	<0.5
<b>MW-8U</b>	8/23/94 @1240	4.19	* 0	393	3630	15922	19.8	<10	7080	7980
<b>MW-8L</b>	8/23/94 @1216	6.56	* 0	356	120	1383	13.8	3.60	146	148
<b>MW-9</b>	8/23/94 @0955	7.33	49.6	24.5	2.01	69.5	1.56	<1	1.60	<0.5
<b>MW-11</b>	8/22/94 @1703	7.22	49.1	30.2	3.72	90.8	2.15	1.30	27.4	24.8
<b>MW-12</b>	8/23/94 @0830	7.58	69.9	36.2	4.77	110	2.70	2.20	2.80	0.900
<b>MW-13</b>	8/23/94 @1245	5.94	5.69	337	249	1866	22.5	9.50	5120	4610
<b>MW-14</b>	8/22/94 @1519	7.59	131	393	60.9	1233	12.1	3.10	0.700	<0.5
<b>#1121</b>	8/24/94 @1121	-----	-----	-----	-----	-----	-----	-----	69.7	-----

NOTES: "-t" = Total Recoverable      "-d" = Dissolved  
 \* pH < 4.5; Alkalinity = 0

# **FRENCH GULCH CHEMISTRY DATA - August 22-24, 1994**

Sampling Station	Sample Collection Date & Time	pH su	Alk. mg/l	Hardness mg/l	Cr-t ug/l	Cr-d ug/l	Cu-t ug/l	Cu-d ug/l	Ag-t ug/l	Ag-d ug/l
<b>KDS</b>	8/23/94 @1250	6.56	66.3	222	<5	6.00	5.70	<1	0.300	<0.3
<b>MW-1</b>	8/23/94 @1538	8.26	* 0	817	<5	7.00	294	<1	<0.3	<0.3
<b>MW-2</b>	8/23/94 @1118	7.31	* 0	1721	<5	<5	<1	<1	<0.3	<0.3
<b>MW-3</b>	8/23/94 @1150	6.53	* 0	1225	<5	<5	<1	<1	<0.3	<0.3
<b>MW-4</b>	8/23/94 @1500	7.34	4.61	1329	<5	6.00	<1	<1	<0.3	<0.3
<b>MW-5</b>	8/23/94 @1620	7.61	16.2	1289	<5	6.00	<1	<1	<0.3	<0.3
<b>MW-6U</b>	8/23/94 @1045	6.40	* 0	1349	<5	<5	<1	<1	<0.3	<0.3
<b>MW-6L</b>	8/23/94 @1020	6.78	62.7	1467	<5	<5	<1	<1	<0.3	<0.3
<b>MW-7U</b>	8/23/94 @0920	7.36	5.25	342	<5	<5	1.80	<1	<0.3	<0.3
<b>MW-7L</b>	8/23/94 @0845	7.17	10.9	391	<5	<5	<1	<1	<0.3	<0.3
<b>MW-8U</b>	8/23/94 @1240	4.19	* 0	15922	21.0	<50	2570	3890	320	220
<b>MW-8L</b>	8/23/94 @1216	6.56	* 0	1383	<5	5.00	<1	<1	<0.3	<0.3
<b>MW-9</b>	8/23/94 @0955	7.33	49.6	69.5	<5	<5	5.00	<1	<0.3	<0.3
<b>MW-11</b>	8/22/94 @1703	7.22	49.1	90.8	<5	<5	4.00	2.10	<0.3	<0.3
<b>MW-12</b>	8/23/94 @0830	7.58	69.9	110	<5	<5	6.10	1.70	<0.3	<0.3
<b>MW-13</b>	8/23/94 @1245	5.94	5.69	1866	45.0	6.00	21.4	8.10	<0.3	<0.3
<b>MW-14</b>	8/22/94 @1519	7.59	131	1233	<5	<5	1.60	<1	<0.3	<0.3
<b>#1121</b>	8/24/94 @1121	-----	-----	-----	<5	-----	4.00	-----	<0.3	-----

NOTES: "-t" = Total Recoverable "-d" = Dissolved

\* pH < 4.5; Alkalinity = 0

# **FRENCH GULCH CHEMISTRY DATA - August 22-24, 1994**

Sampling Station	Sample Collection Date & Time	pH su	Alk. mg/l	Hardness mg/l	Zn-t ug/l	Zn-d ug/l	Al-t ug/l	Al-d ug/l	Fe-t ug/l	Fe-d ug/l
<b>KDS</b>	8/23/94 @1250	6.56	66.3	222	5385	4051	449	42.0	3913	191
<b>MW-1</b>	8/23/94 @1538	8.26	* 0	817	62998	65083	3089	37.0	70214	48668
<b>MW-2</b>	8/23/94 @1118	7.31	* 0	1721	80553	74910	<30	<30	177109	169744
<b>MW-3</b>	8/23/94 @1150	6.53	* 0	1225	144860	141380	114	45.0	267743	261387
<b>MW-4</b>	8/23/94 @1500	7.34	4.61	1329	105090	113400	60	<30	81048	90976
<b>MW-5</b>	8/23/94 @1620	7.61	16.2	1289	107130	108300	422	33.0	98710	99890
<b>MW-6U</b>	8/23/94 @1045	6.40	* 0	1349	163000	151610	176	33.0	373000	364058
<b>MW-6L</b>	8/23/94 @1020	6.78	62.7	1467	39369	38635	<30	<30	55076	54511
<b>MW-7U</b>	8/23/94 @0920	7.36	5.25	342	18660	18000	676	<30	36186	33070
<b>MW-7L</b>	8/23/94 @0845	7.17	10.9	391	18180	18000	31.0	<30	41561	41072
<b>MW-8U</b>	8/23/94 @1240	4.19	* 0	15922	1863000	1870000	682000	500000	8900000	8400000
<b>MW-8L</b>	8/23/94 @1216	6.56	* 0	1383	148780	151040	270	45.0	99888	103007
<b>MW-9</b>	8/23/94 @0955	7.33	49.6	69.5	153	43.0	663	<30	977	<5
<b>MW-11</b>	8/22/94 @1703	7.22	49.1	90.8	2630	2700	79.0	<30	286	<5
<b>MW-12</b>	8/23/94 @0830	7.58	69.9	110	505	118	4376	33.0	6017	15.0
<b>MW-13</b>	8/23/94 @1245	5.94	5.69	1866	1544000	1650000	916	415	20700	15050
<b>MW-14</b>	8/22/94 @1519	7.59	131	1233	26.0	20.0	<30	<30	3090	3175
<b>#1121</b>	8/24/94 @1121	-----	-----	-----	27974	-----	<30	-----	103	-----

NOTES: "-t" = Total Recoverable "-d" = Dissolved

\* pH < 4.5; Alkalinity = 0

## FRENCH GULCH CHEMISTRY DATA - August 22-24, 1994

Sampling Station	Sample Collection Date & Time	pH su	Alk. mg/l	Hardness mg/l	Pb-t ug/l	Pb-d ug/l	Mn-t ug/l	Mn-d ug/l	Ni-t ug/l	Ni-d ug/l
<b>KDS</b>	8/23/94 @1250	6.56	66.3	222	24.6	<1	6225	5345	21.0	<12
<b>MW-1</b>	8/23/94 @1538	8.26	* 0	817	611	6.60	28979	28978	101	82.0
<b>MW-2</b>	8/23/94 @1118	7.31	* 0	1721	15.5	<1	36518	34201	160	140
<b>MW-3</b>	8/23/94 @1150	6.53	* 0	1225	150	109	51982	48686	137	128
<b>MW-4</b>	8/23/94 @1500	7.34	4.61	1329	27.8	2.40	30684	31715	151	160
<b>MW-5</b>	8/23/94 @1620	7.61	16.2	1289	62.0	9.90	33405	31906	134	111
<b>MW-6U</b>	8/23/94 @1045	6.40	* 0	1349	217	36.9	43875	45920	144	162
<b>MW-6L</b>	8/23/94 @1020	6.78	62.7	1467	15.7	4.30	20969	19771	140	128
<b>MW-7U</b>	8/23/94 @0920	7.36	5.25	342	125	<1	11367	11598	17.0	13.0
<b>MW-7L</b>	8/23/94 @0845	7.17	10.9	391	3.20	<1	13216	13243	14.0	17.0
<b>MW-8U</b>	8/23/94 @1240	4.19	* 0	15922	2000	1060	232000	207000	920	917
<b>MW-8L</b>	8/23/94 @1216	6.56	* 0	1383	44.0	17.0	40934	40073	131	126
<b>MW-9</b>	8/23/94 @0955	7.33	49.6	69.5	16.1	<1	197	22.0	<12	<12
<b>MW-11</b>	8/22/94 @1703	7.22	49.1	90.8	47.2	9.10	48.0	32.0	<12	<12
<b>MW-12</b>	8/23/94 @0830	7.58	69.9	110	17.5	<1	307	163	<12	<12
<b>MW-13</b>	8/23/94 @1245	5.94	5.69	1866	1120	506	164000	188000	1036	900
<b>MW-14</b>	8/22/94 @1519	7.59	131	1233	<1	<1	1289	1306	<12	<12
<b>#1121</b>	8/24/94 @1121	----	----	----	6.80	----	7350	----	31.0	----

NOTES: "-t" = Total Recoverable    "-d" = Dissolved  
 \* pH < 4.5; Alkalinity = 0

# **FRENCH GULCH CHEMISTRY DATA: June 10–12, 1996**

Sampling Station	Sample Collection Date & Time	Flow cfs	Temp °C	Field Measurements		pH su	DO mg/l	Alk mg/l	TSS mg/l	NH <sub>3</sub> mg/l	NO <sub>2</sub> /NO <sub>3</sub> mg/l	PO <sub>4</sub> mg/l
				Conductivity $\mu$ mhos/cm	Conductivity $\mu$ siemens/cm							
MW-1	6/11/96 @1540	-----	11.2	2390	<sup>Δ</sup> 2601	6.05	-----	117	7	0.14	<0.05	<0.02
MW-2*	6/13/96 @1132	-----	10.9	2380	3050	6.40	0.40	212	29	0.24	<0.05	<0.02
MW-3	6/10/96 @1625	-----	9.5	2790	<sup>Δ</sup> 3057	6.12	-----	64.2	12	0.27	<0.05	<0.02
MSRW-3	6/10/96 @1535	-----	10.3	2680	<sup>Δ</sup> 2857	5.71	-----	8.65	46	0.12	<0.05	<0.02
MW-6U*	6/12/96 @1412	-----	8.1	2500	3030	5.62	1.67	35.8	49	0.24	<0.05	<0.02
MW-7U	6/11/96 @1420	-----	6.2	911	<sup>Δ</sup> 978	6.84	-----	53.6	8	0.19	<0.05	<0.02
MW-7L	6/11/96 @1145	-----	9.0	904	<sup>Δ</sup> 997	6.56	-----	72.9	4	0.19	<0.05	<0.02
MW-8M* Both	6/13/96 @0945	-----	10.3	2680	3200	5.82	2.3	99.1	27	0.14	<0.05	0.09
MW-8M* Mix	6/13/96 @0945	-----	-----	2680	2871	-----	-----	98.7	24	0.13	<0.05	0.09
MW-8U*	6/12/96 @1550	-----	8.5	2630	3170	5.75	2.5	97.1	12	0.18	0.07	0.04
MW-9	6/10/96 @1714	-----	5.9	385	<sup>Δ</sup> 402	7.52	-----	103	<4	<0.05	<0.05	0.02
MW-12*	6/11/96 @1000	-----	13.5	-----	258	6.70	-----	46.4	21	<0.05	0.31	0.06
MW-13*	6/14/96 @1030	-----	-----	5530	6700	4.7	0.35	38.3	14	0.24	0.16	0.04
MW-14	6/10/96 @1648	-----	7.0	-----	-----	6.99	-----	223	20	0.07	<0.05	<0.02
MW-15*	6/11/96 @1430	-----	5.6	185	208	7.42	1.92	77.9	18	<0.05	<0.05	0.05
MW-16	6/10/96 @1554	-----	11.1	2330	<sup>Δ</sup> 2533	6.14	-----	116	68	0.13	<0.05	<0.02
MW-20*	6/12/96 @1030	-----	5.4	191	195	6.48	1.08	62.3	<4	<0.05	<0.05	0.03
ORO-1*	6/11/96 @1730	-----	8.9	1907	2050	5.51	0.48	15.6	12	0.14	<0.05	<0.02
SB-RF3*	6/12/96 @1620	-----	11.5	11000	13180	4.16	4.8	<5	99	4.21	0.13	0.03

\* Field measurements for these sites were taken by USGS.

<sup>Δ</sup> EPA conductivities were taken in the lab due to problems with the probe in the field. Conductivities were originally measured in  $\mu$ mhos/cm but were corrected to  $\mu$ siemens/cm using a YSI formula.



# FRENCH GULCH CHEMISTRY DATA: June 10-12, 1996

Sampling Station	Sample Collection Date & Time	F mg/l	Cl mg/l	SO <sub>4</sub> mg/l	Br mg/l	TOC mg/l	Hg-t µg/l	Ca-d mg/l	Mg-d mg/l	Hardness mg/l	Na-d mg/l	K-d mg/l
MW-1	6/11/96 @1540	<0.2	1.85	2520	<0.5	<1.5	-----	416.3	138.9	1610	13.27	4.1
MW-2	6/13/96 @1132	<0.2	1.93	2410	<0.5	<1.5	<0.2	552.0	132.4	1920	12.81	1.7
MW-3	6/10/96 @1625	<0.2	<0.5	" 2920	<0.5	1.8	<0.2	391.4	179.9	1720	10.98	4.4
MSRW-3	6/10/96 @1535	<0.2	4.12	" 2360	<0.5	1.7	-----	393.0	135.6	1540	13.07	5.7
MW-6U	6/12/96 @1412	<0.2	2.98	2640	<0.5	<1.5	<0.2	442.0	142.3	1690	14.96	3.2
MW-7U	6/11/96 @1420	<0.2	1.40	755	<0.5	<1.5	-----	145.1	41.77	534	4.54	2.0
MW-7L	6/11/96 @1145	<0.2	1.40	737	<0.5	<1.5	-----	159.6	43.93	579	4.90	2.1
MW-8M Both	6/13/96 @0945	<0.2	2.34	2730	<0.5	<1.5	<0.2	432.0	157.7	1730	12.73	3.1
MW-8M Mix	6/13/96 @0945	<0.2	2.35	2690	<0.5	<1.5	<0.2	437.2	160.6	1750	12.85	3.3
MW-8U	6/12/96 @1550	<0.2	2.41	2750	<0.5	<1.5	<0.2	491.0	171.0	1930	14.80	4.6
MW-9	6/10/96 @1714	<0.2	1.34	116	1.06	1.8	-----	76.77	6.28	218	2.50	1.9
MW-12	6/11/96 @1000	<0.2	1.35	71.0	<0.5	<1.5	-----	38.32	5.47	118	2.11	1.6
MW-13	6/14/96 @1030	<0.2	4.62	7830	<0.5	<1.5	<0.2	473.0	383.1	2760	18.39	12.2
MW-14	6/10/96 @1648	<0.2	2.09	1910	<0.5	2.5	-----	590.5	100.5	1890	13.58	4.9
MW-15	6/11/96 @1430	<0.2	1.35	33.6	<0.5	<1.5	-----	39.45	2.40	108	2.27	<1
MW-16	6/10/96 @1554	<0.2	2.70	" 2280	<0.5	<1.5	<0.2	472.7	139.0	1750	13.66	4.7
MW-20	6/12/96 @1030	<0.2	1.32	41.0	<0.5	<1.5	-----	28.62	4.27	89.0	8.99	1.0
ORO-1	6/11/96 @1730	<0.2	2.71	1740	<0.5	1.9	-----	280.5	93.37	1080	9.67	4.7
SB-RF3	6/12/96 @1620	° <0.2	° 2.79	° 19200	° <0.5	11.7	<0.2	431.5	374.4	2620	16.87	<10

⌘ 28 Day Holding Time was exceeded.

° Spike values for anions were out of control limits. Values are suspect.

NOTE: "-t" = Total Recoverable      "-d" = Dissolved

# FRENCH GULCH CHEMISTRY DATA: June 10-12, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk. mg/l	Hardness mg/l	Cd-t µg/l	Cd-d µg/l	Cr-t µg/l	Cr-d µg/l	Cu-t µg/l	Cu-d µg/l	Ag-t µg/l	Ag-d µg/l
MW-1	6/11/96 @1540	6.05	117	1610	163	159	<4	<4	6.2	4.1	<0.2	<0.2
MW-2	6/13/96 @1132	6.40	212	1920	6.4	6.2	<4	<4	<0.8	<0.8	<0.2	<0.2
MW-3	6/10/96 @1625	6.12	64.2	1720	318	312	<4	<4	17.2	<0.8	<0.2	<0.2
MSRW-3	6/10/96 @1535	5.71	8.65	1540	651	657	<4	<4	260.9	219	<0.2	<0.2
MW-6U	6/12/96 @1412	5.62	35.8	1690	143	147	<4	<4	26.6	22.8	<0.2	<0.2
MW-7U	6/11/96 @1420	6.84	53.6	534	2	1.0	<4	<4	<0.8	<0.8	<0.2	<0.2
MW-7L	6/11/96 @1145	6.56	72.9	579	1.6	0.8	<4	<4	<0.8	<0.8	<0.2	<0.2
MW-8M Both	6/13/96 @0945	5.82	99.1	1730	398	404	<4	<4	<0.8	<0.8	<0.2	<0.2
MW-8M Mix	6/13/96 @0945	-----	98.7	1750	395	412	<4	<4	<0.8	<0.8	<0.2	<0.2
MW-8U	6/12/96 @1550	5.75	97.1	1930	392	426	<4	<4	<0.8	<0.8	<0.2	<0.2
MW-9	6/10/96 @1714	7.52	103	218	2.4	2.1	<4	<4	3.2	2.1	0.20	<0.2
MW-12	6/11/96 @1000	6.70	46.4	118	2.3	1.1	9.8	<4	7.0	1.0	<0.2	<0.2
MW-13	6/14/96 @1030	4.7	38.3	2760	5380	5710	<4	<4	17.8	9.2	<0.2	<0.2
MW-14	6/10/96 @1648	5.99	223	1890	0.7	<0.5	<4	<4	<0.8	<0.8	<0.2	<0.2
MW-15	6/11/96 @1430	7.42	77.9	108	<0.5	0.6	<4	<4	10.1	1.4	0.70	<0.2
MW-16	6/10/96 @1554	6.14	116	1750	58.5	58.0	<4	<4	<0.8	<0.8	<0.2	<0.2
MW-20	6/12/96 @1030	6.48	62.3	89.0	<0.5	<0.5	4.4	<4	1.9	1.2	<0.2	<0.2
ORO-1	6/11/96 @1730	5.51	15.6	1080	278	271	<4	<4	37.0	17.2	0.60	<0.2
SB-RF3	6/12/96 @1620	4.16	<5	2620	14600	14300	<40	<40	6812.0	7000.0	1.00	0.30

NOTE: "-t" = Total Recoverable      "-d" = Dissolved

# **FRENCH GULCH CHEMISTRY DATA: June 10-12, 1996**

Sampling Station	Sample Collection Date & Time	pH su	Alk. mg/l	Hardness mg/l	Zn-t µg/l	Zn-d µg/l	Al-t µg/l	Al-d µg/l	Fe-t µg/l	Fe-d µg/l	Pb-t µg/l	Pb-d µg/l
<b>MW-1</b>	6/11/96 @1540	6.05	117	1610	187370	180760	96	52	162980	159319	448.0	316.8
<b>MW-2</b>	6/13/96 @1132	6.40	212	1920	79599	73900	<40	<40	154953	141607	1.3	<0.8
<b>MW-3</b>	6/10/96 @1625	6.12	64.2	1720	253190	245600	1412	94	294692	283519	534.8	309.3
<b>MSRW-3</b>	6/10/96 @1535	5.71	8.65	1540	216770	213210	2500	1351	175133	172567	577.2	373.3
<b>MW-6U</b>	6/12/96 @1412	5.62	35.8	1690	166770	173000	9606	1377	276507	281000	301.1	113.3
<b>MW-7U</b>	6/11/96 @1420	6.84	53.6	534	40007	42446	103	<40	71912.9	77407.7	11.8	<0.8
<b>MW-7L</b>	6/11/96 @1145	6.56	72.9	579	33842	34209	51	<40	70314.5	71545.2	6.0	1.1
<b>MW-8M Both</b>	6/13/96 @0945	5.82	99.1	1730	241580	235660	638	54	160500	158000	99.3	27.6
<b>MW-8M Mix</b>	6/13/96 @0945	-----	98.7	1750	240860	239170	638	55	160925	161392	97.7	30.7
<b>MW-8U</b>	6/12/96 @1550	5.75	97.1	1930	239240	261000	546	129	154199	168000	86.9	27.5
<b>MW-9</b>	6/10/96 @1714	7.52	103	218	66.2	224	91	<40	180.6	35.1	4.6	<0.8
<b>MW-12</b>	6/11/96 @1000	6.70	46.4	118	280.9	178	1547	<40	1482.2	<5	4.9	<0.8
<b>MW-13</b>	6/14/96 @1030	4.7	38.3	2760	1072100	1076900	710	606	12161.4	13373.8	680.5	683.6
<b>MW-14</b>	6/10/96 @1648	6.99	223	1890	5278.4	4923	<40	<40	16643.0	16446.1	2.4	<0.8
<b>MW-15</b>	6/11/96 @1430	7.42	77.9	108	219.7	<4	7000	<40	5008.5	<5	30.2	<0.8
<b>MW-16</b>	6/10/96 @1554	6.14	116	1750	126070	126320	1441	<40	121620	120540	17.1	<0.8
<b>MW-20</b>	6/12/96 @1030	6.48	62.3	89.0	32.8	30.4	639	<40	504.3	8.2	2.1	<0.8
<b>ORO-1</b>	6/11/96 @1730	5.51	15.6	1080	166910	156710	629	428	90187.6	84371.4	453.3	262.3
<b>SB-RF3</b>	6/12/96 @1620	4.16	<5	2620	3155500	3090000	251480	256000	4467030	4450000	1203.1	1113.0

NOTE: "-t" = Total Recoverable      "-d" = Dissolved

# **FRENCH GULCH CHEMISTRY DATA: June 10-12, 1996**

Sampling Station	Sample Collection Date & Time	pH su	Alk. mg/l	Hardness mg/l	Mn-t µg/l	Mn-d µg/l	Ni-t µg/l	Ni-d µg/l	As-t µg/l	As-d µg/l
MW-1	6/11/96 @1540	6.05	117	1610	49876.0	49205.5	154.2	152.6	35.3	34.2
MW-2	6/13/96 @1132	6.40	212	1920	38612.2	36063.0	155.8	146.9	28.7	34.7
MW-3	6/10/96 @1625	6.12	64.2	1720	108700	109365	242.6	233.6	22.9	14.2
MSRW-3	6/10/96 @1535	5.71	8.65	1540	50029.5	50711.5	141.2	135.0	16.2	13.0
MW-6U	6/12/96 @1412	5.62	35.8	1690	50276.3	52800.0	193.5	195.9	22.0	21.3
MW-7U	6/11/96 @1420	6.84	53.6	534	17831.7	19153.5	26.9	25.2	2.4	1.6
MW-7L	6/11/96 @1145	6.56	72.9	579	20367.8	20673.5	25.3	30.4	2.7	2.3
MW-8M Both	6/13/96 @0945	5.82	99.1	1730	60132.0	61716.1	172.0	162.7	49.9	46.7
MW-8M Mix	6/13/96 @0945	-----	98.7	1750	60339.4	63124.6	179.0	168.6	50.0	45.0
MW-8U	6/12/96 @1550	5.75	97.1	1930	59803.0	68031.0	162.2	150.0	40.4	45.2
MW-9	6/10/96 @1714	7.52	103	218	36.1	49.2	<10	<10	<0.8	<0.8
MW-12	6/11/96 @1000	6.70	46.4	118	80.5	41.8	<10	<10	<0.8	<0.8
MW-13	6/14/96 @1030	4.7	38.3	2760	194410	221751	1167	1185	<0.8	0.9
MW-14	6/10/96 @1648	6.99	223	1890	5216.4	5048.0	12.2	14.6	6.4	6.2
MW-15	6/11/96 @1430	7.42	77.9	108	135.6	3.8	<10	<10	2.9	<0.8
MW-16	6/10/96 @1554	6.14	116	1750	38877.4	39336.6	154.6	150.4	24.9	19.5
MW-20	6/12/96 @1030	6.48	62.3	89.0	44.1	37.8	<10	<10	<0.8	<0.8
ORO-1	6/11/96 @1730	5.51	15.6	1080	36111.1	34203.6	118.2	107.2	9.2	5.8
SB-RF3	6/12/96 @1620	4.16	<5	2620	253987	256600	778.5	668.0	7.6	6.3

NOTE: "-t" = Total Recoverable      "-d" = Dissolved

# FRENCH GULCH BACKGROUND WATER CHEMISTRY DATA: July 22-23, 1996

Sampling Station	Sample Collection Date & Time	Field Measurements			pH su	Alk mg/l	TSS mg/l	F mg/l	Cl mg/l	SO <sub>4</sub> mg/l	Br mg/l
		Flow cfs	Temp °C	Cond µmhos/cm							
MW-1	7/22/96 @1832	-----	8.9	2080	6.31	95.5	31	<0.2	2.01	1880	<0.5
MW-1 Replicate	7/22/96 @1832	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
MW-3	7/22/96 @1855	-----	8.4	2510	5.90	83.2	60	<0.2	2.89	2580	2.13
MSRW-3	7/22/96 @1842	-----	9.2	2110	5.50	21.6	61	0.33	1.96	1960	1.89
MW-9	7/22/96 @1719	-----	7.3	362	7.32	100	<4	0.20	1.52	164	<0.5
MW-16	7/22/96 @1810	-----	9.3	2120	6.22	126	38	<0.2	1.96	1900	<0.5
MW-20	7/22/96 @1702	-----	6.3	259	7.17	94.7	61	0.25	1.64	85.2	<0.5
ORO-1	7/22/96 @1740	-----	9.0	1530	5.02	6.10	34	0.64	2.71	1290	<0.5

# FRENCH GULCH BACKGROUND WATER CHEMISTRY DATA: July 22-23, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk mg/l	Hardness mg/l	Ni-t µg/l	Ni-d µg/l	As-t µg/l	As-d µg/l
MW-1	7/22/96 @1832	6.31	95.5	1480	140.5	147.2	75.30	39.60
MW-1 Replicate	7/22/96 @1832	-----	-----	-----	141.2	-----	71.20	-----
MW-3	7/22/96 @1855	5.90	83.2	1540	202.6	195.8	31.40	21.70
MSRW-3	7/22/96 @1842	5.50	21.6	1470	112.9	118.5	10.80	4.70
MW-9	7/22/96 @1719	7.32	100	257	<10	<10	<1	<1
MW-16	7/22/96 @1810	6.22	126	1600	154.6	146.3	32.00	19.10
MW-20	7/22/96 @1702	7.17	94.7	135	<10	<10	3.80	<1
ORO-1	7/22/96 @1740	5.02	6.10	947	112.9	121.7	12.50	6.60

NOTE: "-t" = Total Recoverable      "-d" = Dissolved

# FRENCH GULCH BACKGROUND WATER CHEMISTRY DATA: July 22-23, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk mg/l	Hardness mg/l	Fe-t µg/l	Fe-d µg/l	Pb-t µg/l	Pb-d µg/l	Mn-t µg/l	Mn-d µg/l
<b>MW-1</b>	7/22/96 @1832	6.31	95.5	1480	166050	149110	1233.3	509.37	47035.4	45718.2
<b>MW-1</b> Replicate	7/22/96 @1832	-----	-----	-----	165320	-----	1232.1	-----	46986.0	-----
<b>MW-3</b>	7/22/96 @1855	5.90	83.2	1540	368280	325160	486.62	374.40	82210.2	76710.5
<b>MSRW-3</b>	7/22/96 @1842	5.50	21.6	1470	175680	163590	727.59	327.22	49179.8	50192.4
<b>MW-9</b>	7/22/96 @1719	7.32	100	257	247.4	10.4	5.3	<0.8	112.9	94.0
<b>MW-16</b>	7/22/96 @1810	6.22	126	1600	131800	119050	21.8	5.6	40329.5	38889.7
<b>MW-20</b>	7/22/96 @1702	7.17	94.7	135	4187.8	<5	17.8	<0.8	143.4	45.2
<b>ORO-1</b>	7/22/96 @1740	5.02	6.10	947	76830	68890	820.57	608.60	33919.2	32647.4

NOTE: "-t" = Total Recoverable    "-d" = Dissolved

# FRENCH GULCH BACKGROUND WATER CHEMISTRY DATA: July 22-23, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk mg/l	Hardness mg/l	Ag-t µg/l	Ag-d µg/l	Zn-t µg/l	Zn-d µg/l	Al-t µg/l	Al-d µg/l
MW-1	7/22/96 @1832	6.31	95.5	1480	<0.2	<0.2	191010	177090	560	180
MW-1 Replicate	7/22/96 @1832	-----	-----	-----	<0.2	-----	190660	-----	583	-----
MW-3	7/22/96 @1855	5.90	83.2	1540	<0.2	<0.2	230010	205120	1979	81
MSRW-3	7/22/96 @1842	5.50	21.6	1470	<0.2	<0.2	213800	205700	4063	1050
MW-9	7/22/96 @1719	7.32	100	257	<0.2	<0.2	100.9	92.5	60	<40
MW-16	7/22/96 @1810	6.22	126	1600	<0.2	<0.2	142660	131150	1128	<40
MW-20	7/22/96 @1702	7.17	94.7	135	<0.2	<0.2	142.8	38.7	3817	<40
ORO-1	7/22/96 @1740	5.02	6.10	947	1.10	<0.2	166840	155530	2577	1905

NOTE: "-t" = Total Recoverable      "-d" = Dissolved



# **FRENCH GULCH BACKGROUND WATER CHEMISTRY DATA: July 22-23, 1996**

Sampling Station	Sample Collection Date & Time	pH su	Alk mg/l	Hardness mg/l	Cd-t µg/l	Cd-d µg/l	Cr-t µg/l	Cr-d µg/l	Cu-t µg/l	Cu-d µg/l
<b>MW-1</b>	7/22/96 @1832	6.31	95.5	1480	187	156	<4	<4	186.6	20.2
<b>MW-1</b> Replicate	7/22/96 @1832	-----	-----	-----	186	-----	<4	-----	190.0	-----
<b>MW-3</b>	7/22/96 @1855	5.90	83.2	1540	193	173	<4	<4	12.4	<0.8
<b>MSRW-3</b>	7/22/96 @1842	5.50	21.6	1470	597	589	<4	<4	207.1	183.7
<b>MW-9</b>	7/22/96 @1719	7.32	100	257	2.6	2.1	<4	<4	1.0	<0.8
<b>MW-16</b>	7/22/96 @1810	6.22	126	1600	91.3	78.4	<4	<4	1.9	<0.8
<b>MW-20</b>	7/22/96 @1702	7.17	94.7	135	2.5	1.9	<4	<4	10.9	1.4
<b>ORO-1</b>	7/22/96 @1740	5.02	6.10	947	343	323	<4	<4	178.9	69.6

NOTE: "-t" = Total Recoverable      "-d" = Dissolved

# FRENCH GULCH BACKGROUND WATER CHEMISTRY DATA: July 22-23, 1996

Sampling Station	Sample Collection Date & Time	TOC mg/l	NH <sub>3</sub> mg/l	NO <sub>2</sub> /NO <sub>3</sub> mg/l	PO <sub>4</sub> mg/l	Ca-d mg/l	Mg-d mg/l	Hardness mg/l	Na-d mg/l	K-d mg/l
MW-1	7/22/96 @1832	<1.5	0.19	0.05	0.05	385.6	126.4	1480	13.31	3.9
MW-1 Replicate	7/22/96 @1832	-----	-----	-----	-----	-----	-----	-----	-----	-----
MW-3	7/22/96 @1855	1.6	0.40	0.07	<0.02	380.4	144.5	1540	11.67	4.4
MSRW-3	7/22/96 @1842	1.6	0.17	0.05	0.02	376.0	130.1	1470	12.81	2.4
MW-9	7/22/96 @1719	<1.5	<0.05	<0.05	<0.02	90.80	7.39	257	2.79	1.1
MW-16	7/22/96 @1810	<1.5	0.16	<0.05	<0.02	432.8	126.3	1600	13.15	1.1
MW-20	7/22/96 @1702	<1.5	<0.05	<0.05	0.07	43.08	6.55	135	22.57	1.7
ORO-1	7/22/96 @1740	6.7	0.21	<0.05	0.03	242.5	82.98	947	9.34	4.5

NOTE: "-d" = Dissolved

**TABLE 2: WELLINGTON ORO MINE SITE**  
**DOMESTIC WELL SAMPLING RESULTS**  
Total and Dissolved Metals (ug/L) page 1 of 2

	BACKGROUND		NORTH SIDE FRENCH CREEK								
	GW-01	GW-02	GW-03	GW-04	GW-05	GW-06	GW-07	GW-08	GW-09		
Location	Background	Background		Industrial	Peak 8	Huron Hts	Huron Hts	Huron Hts	Huron Hts		
Address	3821 FCR	3882 FCR	1321 FCR	Park	Trailer Park	347 Huron	72 CR 451	457 CR 451	151 CR 451		
Name	Griggs	Peters	Johnsons	Not for DW	Dowdy	Teals	Neels	Phillips	McDowell		
Treatment System	Softener, Filter	Softener, Filter	None	None	Chlorination	None	Unknown	None	Filter		
Water Sampled	Untreated	Untreated	Untreated	Untreated	Untreated	Untreated	Outside ?	Untreated	Untreated		
Well Depth	Unknown	55 Feet	125 Feet	Unknown	Unknown	65 Feet	Unknown	Unknown	125 Feet		
Cadmium T	4.90 B	1.10 U	1.10 U	28.30	1.10 U	1.10 U	7.10	1.10 U	1.10 U		
Cadmium D	4.70 B	1.10 U	1.10 U	25.30	1.10 U	1.10 U	5.80	1.10 U	1.10 U		
Calcium T	51100.00	39700.00	85700.00	52600.00	88500.00	76500.00	67600.00	81700.00	47700.00		
Calcium D	50500.00	36900.00	82500.00	51700.00	76500.00	78300.00	56800.00	81000.00	46400.00		
Cobalt T	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U		
Cobalt D	1.00 U	1.10 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U		
Copper T	3.60 B	71.30	30.90	16.00 B	3.90 B	13.90 B	249.00	19.20 B	2.80 B		
Copper D	2.00 B	59.70	26.40	62.30	1.30 B	18.90 B	165.00	16.00 B	1.20 U		
Iron T	1030.00 J	1930.00 J	108.00 J	55.30 U	74.60 U	139.00 J	76.10 U	58.70 U	48.20 U		
Iron D	929.00 J	33.00 U	85.40 U	47.70 U	70.30 U	71.30 U	55.50 U	52.90 U	50.00 U		
Lead T	17.30	2.90 U	1.50 U	6.20 U	2.40 U	3.20 U	4.20 U	3.00 U	2.00 U		
Lead D	14.40	1.60 B	4.20	8.60	1.40 U	4.80 U	3.50	1.40 U	1.70 B		
Magnesium T	7320.00	3960.00 B	20300.00	10200.00	15300.00	13700.00	11700.00	14000.00	6610.00		
Magnesium D	7220.00	3610.00 B	19500.00	9870.00	13200.00	14000.00	9920.00	13900.00	6430.00		
Manganese T	653.00	7.70 B	6.80 B	1.50 B	4.80 B	4.00 B	2.70 B	6.70 B	104.00		
Manganese D	646.00	3.20 B	6.80 B	1.80 B	3.70 B	3.30 B	1.90 B	8.10 B	103.00		
Nickel T	2.70 U	2.70 U	2.70 U	4.80 B	2.70 U	2.70 U	6.50 B	2.70 U	2.70 U		
Nickel D	2.70 U	2.70 U	2.70 U	4.40 B	2.70 U	2.70 U	5.70 B	2.70 U	2.70 U		
Potassium T	1170.00 BJ	1020.00 BJ	2530.00 BJ	1660.00 BJ	3490.00 BJ	3380.00 BJ	2280.00 BJ	3310.00 BJ	3100.00 BJ		
Potassium D	1200.00	978.00 B	2530.00 B	1900.00	3200.00 B	3520.00 B	2010.00 B	3390.00 B	3180.00 B		
Sodium T	1330.00 B	1560.00 B	6480.00	4530.00 B	30400.00	14100.00	5450.00	8450.00	5680.00		
Sodium D	1220.00 B	1350.00 B	6100.00	4320.00 B	26100.00	13900.00	4330.00 B	8190.00	5430.00		
Zinc T	822.00	40.70	80.70	8190.00	62.50	49.70	2710.00	20.10	335.00		
Zinc D	808.00	28.50 J	72.20 J	6050.00 J	54.50 J	68.40 J	2290.00 J	18.60 BJ	325.00 J		

U not detected

J estimate because the quality control criteria (qcc) were not met

B estimate because the analyte is present at a concentration below the contract required detection limit (CRDL)

Elevated concentration. Value is greater than 3x times background (BG), or if not detected in the BG, concentration is greater than CRDL

**TABLE 2: WELLINGTON ORO MINE SITE**  
**DOMESTIC WELL SAMPLING RESULTS**  
Total and Dissolved Metals (ug/L) page 2 of 2

	SOUTH SIDE FRENCH CREEK						QA SAMPLES			
	GW-10	GW-11	GW-12	GW-13	GW-14	GW-18	GW-15	GW-16	GW-17	
Location	Breck Hts	Breck Hts	Breck Hts	Breck Hts	Breck Hts	Breck Hts	Blank	Blank	Duplicate	
Address	581 High Pt	921 High Pt	781 High Pt	1091 High Pt	491 High Pt	511 High Pt			of GW-04	
Name	Poderecki	Summ	McCleary	Knickrehm	Kuennen	Rahn				
Treatment System	None	None	None	Unknown	Filter, Softener	Filter Softener etc				
Water Sampled	Untreated	Untreated	Untreated	Untreated	Untreated	Filtered only				
Well Depth	150 Feet	140 Feet	140 Feet	Unknown	230 Feet	Unknown				
Cadmium T	1.10 U	1.10 U	1.10 U	1.10 U	1.10 U	6.80	1.10 U	1.10 U	26.10	
Cadmium D	1.10 U	1.40 U	1.10 U	1.10 U	1.10 U	6.70	1.10 U	1.10 U	25.90	
Calcium T	23700.00	22700.00	22000.00	16600.00	17300.00	10500.00	394.00 B	1000.00 U	53100.00	
Calcium D	21800.00	22400.00	22200.00	16000.00	17100.00	10500.00	443.00 B	650.00 U	52600.00	
Cobalt T	1.00 U	1.00 U	1.00 U	1.00 U	21.80 B	9.50 B	1.00 U	1.00 U	1.00 U	
Cobalt D	1.20 B	1.00 U	1.00 U	1.00 U	21.60 B	9.60 B	1.00 U	1.00 U	1.00 U	
Copper T	220.00	23.40 B	20.40 B	73.10	75.20	358.00	1.30 B	3.30 B	70.50	
Copper D	325.00	21.60 B	27.50	56.70	21.60 B	290.00	1.20 B	1.20 U	66.30	
Iron T	64.90 U	50.80 U	29.80 U	25.70 U	12800.00 J	3180.00 J	16.00 U	23.50 U	74.60 U	
Iron D	28.90 U	33.70 U	203.00 J	33.40 U	1710.00 J	875.00 J	19.20 U	28.00 U	51.30 U	
Lead T	2.80 U	1.40 U	3.10 U	1.50 U	3.50 U	14.40	1.40 U	1.40 U	1.40 U	
Lead D	3.80	2.70 B	1.70 B	1.90 B	3.00 B	4.60	1.60 B	1.40 U	1.40 U	
Magnesium T	5690.00	6720.00	8990.00	4440.00 B	6070.00	3130.00 B	35.10 U	157.00 U	10200.00	
Magnesium D	5330.00	6660.00	8310.00	4290.00 B	6020.00	3120.00 B	56.90 U	88.00 U	10100.00	
Manganese T	194.00	10.70 B	1.90 B	0.60 U	10200.00	7180.00	1.50 B	0.60 U	11.80 B	
Manganese D	165.00	9.50 B	2.20 B	0.60 U	10100.00	7120.00	0.61 B	16.60	1.90 B	
Nickel T	2.70 U	2.70 U	2.70 U	2.70 U	10.80 B	5.10 B	2.70 U	2.70 U	4.90 B	
Nickel D	2.70 U	2.70 U	2.70 U	2.70 U	11.20 B	5.80 B	2.70 U	2.70 U	5.50 B	
Potassium T	1070.00 BJ	1480.00 BJ	1260.00 BJ	1190.00 BJ	1550.00 BJ	1380.00 BJ	39.20 U	55.80 U	1870.00 BJ	
Potassium D	1090.00 B	1550.00 B	1320.00 B	1240.00 B	1580.00 B	1470.00 B	54.80 U	106.00 U	1960.00	
Sodium T	8260.00	42800.00	7910.00	5380.00	10100.00	8970.00	187.00 U	187.00 U	4580.00 B	
Sodium D	6180.00	41800.00	7290.00	5200.00	9730.00	8710.00	187.00 U	291.00 B	4520.00 B	
Zinc T	55.10	7.10 B	1.10 U	13.00 B	1960.00	668.00	7.90 B	55.80	6210.00	
Zinc D	52.10 J	8.40 BJ	2.90 BJ	13.20 BJ	1910.00 J	664.00 J	8.10 BJ	5.90 BJ	6150.00 J	

U not detected

J estimate because the quality control criteria (qcc) were not met

B estimate because the analyte is present at a concentration below the contract required detection limit (CRDL)

Elevated concentration. Value is greater than 3x times background (BG), or if not detected in the BG, concentration is greater than CRDL

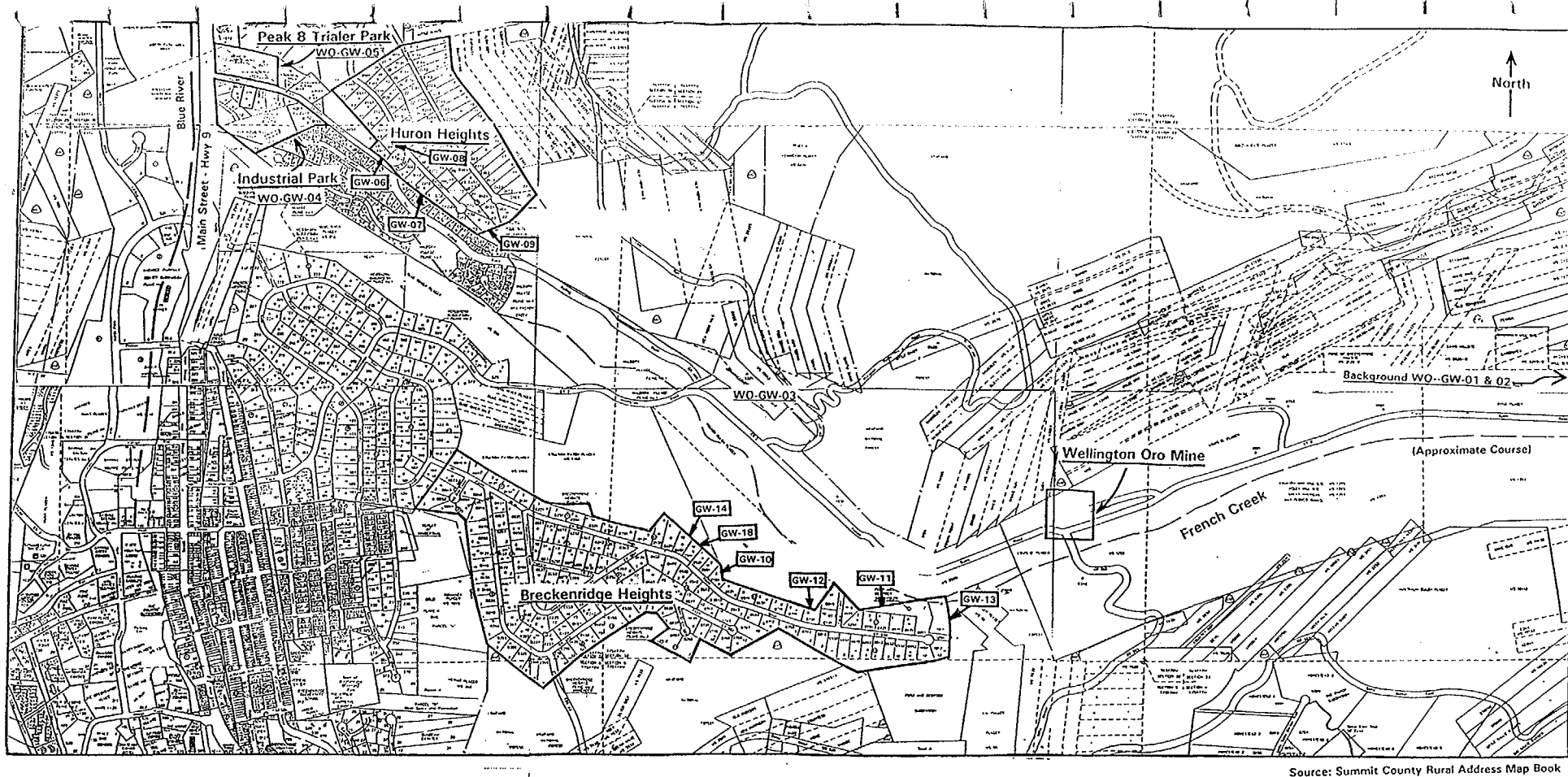


Figure 1 - Ground Water Sample Location Map

## ATTACHMENT D

### Summary of April, 1997 Domestic Well Sampling Results

The October 1996 sampling identified two residences in the Breckenridge Hts area with high levels of manganese 7-10 milligrams per liter. There is no MCL for manganese but the consensus among toxicologists I have spoken to is that people should not be consuming water with greater than 1.0 milligrams per liter and the eventual MCL will likely be lower than that. This sampling only sampled untreated water.

Another round of sampling was performed in April to resample these wells both before and after treatment and to sample additional nearby wells not previously sampled. Here are the results of this sampling

GW-14 (491 High Point). Original Untreated manganese at 10,300 ug/L. A letter advising the occupants not to consume the water was issued on February 12, 1997. This well was not resampled because they did not have their treatment system on-line at the time.

GW-18 (511 High Point). Original Untreated manganese at 7,180 ug/L. A letter advising the occupants not to consume the water was issued on February 12, 1997. The resampling of this well contained 6,250 ug/L before in-house treatment and 758 ug/l after. A letter will be sent along with the results recommending the occupants not consume the water.

GW-19 (451 High Point). New well. This water tested over 6,000 ug/l for the before and after treatment samples. The owner was not home at the time and a neighbor let us in - a bottled water dispenser was in the kitchen. A letter will be sent along with the results recommending the occupants not consume the water.

GW-20 (531 High Point). New well. This water tested 3,250 ug/L before treatment but nondetect (less than 10 ug/L) after. Interestingly, this well also had 12 ppb cadmium (mcl =5) and 42 ppb lead (action level = 15) before treatment and nondetect after. This is the highest lead level seen in any of the domestic samples.

GW-21 (621 High Point). New well. This well tested low manganese at 62.4 ug/L after treatment. I believe the before treatment sample which has similar concentrations for all analytes was not actually untreated. Therefore the results of GW-21A (after treatment) will be qualified accordingly.

GW-23A (471 High Point). New well. This well tested 2000 ug/L manganese after treatment. We were unable to collect a before treatment sample. A letter will be sent along with the results advising the occupants not to drink the water.

### SUMMARY

A cluster of 5 homes located from 451 to 531 High Point Drive have high levels of manganese in untreated water samples. The effectiveness of the in-house treatment systems varies.

**FRENCH GULCH DOMESTIC WELL SAMPLING RESULTS**  
**APRIL 1997 SAMPLING**  
**METALS IN ug/L**

	RESAMPLE		RESAMPLE			RESAMPLE		RESAMPLE		NEW		New	New	New	New	New
Sample ID	GW-01	GW-01B	GW-01A	GW-14	GW-18	GW-18B	GW-18A	GW-19B	GW-19A	GW-20B	GW-20A	GW-21A	GW-23A			
Location				Breck Hts	Breck Hts	Breck Hts	Breck Hts	Breck Hts	Breck Hts	Breck Hts	Breck Hts	Breck Hts	Breck Hts			
Date	Oct 96	Apr 97	Apr 97	Oct 96	Oct 96	Apr 97	Apr 97	Apr 97	Apr 97	Apr 97	Apr 97	Apr 97	Apr 97			
Address	3821 FCR	3821 FCR	3821 fcr	491 High Pt	611 High Pt	611 High Pt	611 High Pt	481 High Pt	481 High Pt	631 High Pt	631 High Pt	621 High Pt	471 High Pt			
Name	Griggs	Griggs	Griggs	Kuennen	Rahn	Rahn	Rahn	Craig	Craig	Combs	Combs	Snead	O'Neill			
Treatment System	Sink Filter, Soft	Sink Filter,Soft	Sink Filter,Soft	Filter, Softener	Filter, Softener	Filter, Softener	Filter, Softener	Unknown	Unknown	Filter,Softener	Filter,Softener	Filter,Softener	Filter			
Water Sampled	UNTREATED	UNTREATED B	TREATED A	Untreated	Filtered only	UNTREATED	TREATED	UNTREATED	TREATED	UNTREATED	TREATED	TREATED	TREATED			
Well Depth	Unknown	Unknown	Unknown	230 Feet	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	280 feet			
Cadmium T	4.90 B	5.00 U	6.00 U	1.10 U	6.80	5.00 U	5.00 U	5.00 U	5.00 U	12.10 U	5.00 U	5.00 U	5.00 U			
Cadmium D	4.70 B			1.10 U	6.70											
Calcium T	61100.00	49600.00	60700.00	17300.00	10600.00	8860.00	1740.00	6390.00	6590.00	3870.00	1000.00 U	11400.00	1370.00			
Calcium D	60500.00			17100.00	10500.00											
Cobalt T	1.00 U	10.00 U	10.00 U	21.80 B	9.60 B	10.00 U	10.00 U	12.00	11.60	10.00 U	10.00 U	10.00 U	10.00			
Cobalt D	1.00 U	U		21.60 B	9.60 B											
Copper T	3.60 B	14.90	10.00 U	75.20	358.00	161.00	64.20	23.30	51.00	212.00	12.20	10.00 U	72.30			
Copper D	2.00 B			21.60 B	290.00											
Iron T	1030.00 J	1240.00	100.00 U	12800.00 J	3180.00 J	6000.00 U	100.00 U	6710.00	3360.00	11300.00	100.00 U	216.00	246.00			
Iron D	929.00 J			1710.00 J	875.00 J											
Lead T	17.30	16.60	3.00 U	3.60 U	14.40	4.90 U	3.00 U	3.00 U	3.00 U	42.60	3.00 U	3.00 U	3.00 U			
Lead D	14.40			3.00 B	4.60											
Magnesium T	7320.00	6830.00	6670.00	6070.00	3130.00 B	2410.00	1000.00 U	1670.00	1750.00	1090.00	1000.00 U	12700.00	3450.00			
Magnesium D	7220.00			6020.00	3120.00 B											
Manganese T	653.00	631.00	122.00	10300.00	7180.00	6260.00	758.00	6090.00	6110.00	3250.00	10.00 U	82.40	2000.00			
Manganese D	648.00			10100.00	7120.00											
Nickel T	2.70 U	20.00 U	20.00 U	10.80 B	5.10 B	20.00 U	20.00 U	20.00 U	20.00 U	20.00 U	20.00 U	20.00 U	20.00 U			
Nickel D	2.70 U			11.20 B	5.80 B											
Potassium T	1170.00 BJ	1000.00 U	1000.00 U	1550.00 BJ	1380.00 BJ	1110.00	1000.00 U	1000.00 U	1000.00 U	1000.00 U	1000.00 U	1000.00 U	2060.00			
Potassium D	1200.00			1680.00 B	1470.00 B											
Sodium T	1330.00 B	1170.00	1180.00	10100.00	8970.00	8240.00	38100.00	8410.00	8460.00	19100.00	27300.00	6330.00	43300.00			
Sodium D	1220.00 B			9730.00	8710.00											
Zinc T	822.00	632.00	622.00	1960.00	668.00	652.00	61.90	724.00	739.00	628.00	20.00 U	20.00 U	334.00			
Zinc D	808.00			1910.00 J	664.00 J											

U not detected

J estimate because the quality control criteria (qcc) were not met

B estimate because the analyte is present at a concentration below the contract required detection limit (CRDL)

GW 18, GW 19, GW 23 - will get "do not drink" letters

STILLSON PATCH PLACER  
MS 1466

BRECKENRIDGE  
HEIGHTS  
FILING No. 2

GW19

GW23

GW14

GW18

GW20

AREA OF  
KNOWN IMPACT  
HIGH MANGANESE CONCENTRATIONS

MS 1466

OK  
GW10 (OCT)

GW21

OK  
GW12

BRECKENRIDGE  
HEIGHTS  
FILING No. 3

T7SR77W  
SECTION 32

ANF



Quantification of metal loading by tracer-injection  
methods in French Gulch, Colorado

By **Briant A. Kimball, Robert L. Runkel, and Linda J. Gerner**

**U.S. Geological Survey Water-Resources Investigations**

**Report 97-xxx**

This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards. Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. government.

**ABSTRACT**

Acid mine drainage degrades the water quality in French Gulch, Colorado, affecting the health of aquatic organisms and fish in this stream that drains to the Blue River. The metals originate from drainage of old mines in the watershed and enter the stream in a complex pattern. Three tracer injections were used to define hydrologic flowpaths and stream hydrologic properties. A lithium chloride tracer in the Oro Shaft of the Wellington-Oro mine indicated no hydrologic connection of the upper mine shaft water with the downgradient alluvium or with the stream. A sodium bromide tracer in an alluvial well did not result in detectable bromide in the downgradient alluvial well or in the stream. Using a sodium chloride tracer and synoptic sampling, the downstream variation of stream discharge and metal concentrations indicated those subreaches of French Gulch where the majority of metal loading occurs. There is substantial inflow of metals where the 11-10 and Bullhide faults cross the stream, and where surface drainage from the Bullhide Fault enters the stream. The loading analysis points out that the pattern of contamination affecting aquatic life in the stream results from ground water and surface inflow from mine pool drainage.

## **INTRODUCTION**

Acid mine drainage degrades the water quality in French Gulch, Colorado, affecting the health of fish and other aquatic organisms in this stream that drains to the Blue and Colorado Rivers. The metals originate from drainage of old mines in the watershed and enter the stream in a complex pattern. Historically, French Gulch has been dredged for placer gold mining and so the hyporheic zone of the stream is unnatural. The hyporheic zone is the area of alluvium that exchanges water with the stream. The loading of metals to the stream is from surface- and ground-water inflows. This complex hydrology has obscured a consistent picture or conceptual model of the interaction of the various sources. Effective remediation at this site requires an understanding of the diverse physical and biogeochemical processes that control spatial profiles of metal concentrations and other acid constituents. Much of this understanding can come from a detailed mass-loading profile of metals in the stream. A tracer-injection experiment was designed to provide a mass-loading curve and to evaluate the effects of instream geochemical processes.

Spatial variations of pH and toxic metals in streams affected by acid mine drainage are the result of the interplay of hydrologic and geochemical processes (Bencala and McKnight, 1987; Broshears and others, 1995). The approach followed in this study uses tracer injection and mass-balance calculations to provide an interpretation of these variations. Tracer-injection methods, combined with computer simulations, have reproduced mass-loading curves with steady-state patterns of observed pH and metal

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concentrations in other streams around the western United States (Kimball and others, 1995; Broshears and others, 1996).

There are two principal objectives of this report. The first objective is to present a characterization of the French Gulch site based on a tracer injection and synoptic sampling. The second objective is to characterize the interactions between ground and surface water. Results of the tracer injection are particular to the hydrologic conditions at the time of the injection. Streamflow in French Gulch changes throughout the year because of the large amount of subsurface flow through the porous dredged cobbles. During snowmelt runoff, there is flow in the north and south branches of French Gulch downstream from the mine (fig. 1). As flow decreases during the summer, parts of the flow go below the surface. At the time of this experiment, flow decreased between sites T1 and T2, and then almost completely vanished between sites T2 and T3. In the vicinity of the 11-10 Fault, however, the flow greatly increased from the discharge of many springs. Flow continued to increase between sites T3 and T4. Downstream from site T4, the flow was complex, with some inflows and several points along the stream at which water visibly flowed from the stream under cobbles. Near 1,730 m, the channel split and about half the flow cascaded to a pond north of the stream. Water flowed out of the pond and was visible on the surface until about 1,920 m, where it went below the cobbles. Some surface drainage that originated at a spring along the Bullhide Fault, entered this side channel at 1,826 m, downstream from the pond. The left channel from the split (near 1,730 m) was the north branch of French Gulch, and visibly flowed all the way to Dead Elk Pond. It received an inflow at 2,150 m that likely was the return of the side channel

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from the pond. Another set of inflows at 2,400 and 2,422 m were from mine drainage on the north side of the canyon. It also could have originated with drainage from the Bullhide Fault, but may have had additional contributions from tailings piles. Flow in the south branch of French Gulch originated about 200 m upstream from Dead Elk Pond and was not visibly connected to the flow in the north branch.

## METHODS

To study the complex hydrology of French Gulch, there were three separate tracer injections. First, there was a slug injection of lithium chloride (LiCl) into the Oro Shaft to define the paths of mine water to the alluvium and the stream. Second, there was another slug injection using sodium bromide (NaBr) into an alluvial well (MW-9) to quantify the interaction of the stream with the alluvium. Third, there was a continuous injection of sodium chloride (NaCl) into the stream to quantify hydrologic parameters. These parameters included discharge at each sampling site along the stream, residence time of solutes between sites, and transient storage (Stream Solute Workshop, 1990; Bencala and others, 1990a, 1990b). The sequence of injections is listed in table 1.

**Table 1—Sequence of tracer injection activities and sampling in French Gulch.**

Date	Time	Event
7/23/96	09:00	Began tracer sampling for wells
	09:15	Slug injection of LiCl into Oro Shaft
	09:38	Slug injection of NaBr into well MW-9
	10:00	Flow-meter discharge measurements at selected stream sites
7/24/96	09:00	Start NaCl injection in the stream (runs into day 5)
	09:00	Began tracer sampling at 6 sites
	14:42	Added salt to pool
	17:24	Added salt to pool
7/25/96	11:12	Started spot tracer injections at 6 sites
	17:20	Added salt to pool
7/26/96	08:00	Synoptic sampling of stream sites and inflows
	11:21	Added salt to pool
7/27/96	09:00	Shut off tracer
	08:30	Time of travel sampling
7/28/96	12:00	End of sampling

## **TRACER SAMPLING**

Samples were collected to measure the injected tracers and to quantify the residence time or "time of travel" in wells and in the stream. Residence-time sampling was in two parts. The first part included sampling of selected wells in the bedrock and alluvium to quantify the arrival of LiCl or NaBr from slug injections. This continued for 4 days, mostly at hourly intervals in 6 wells. Residence-time samples for the wells were unfiltered because of the difficulty of filtering iron-rich waters in the field. The samples were filtered in the laboratory prior to analysis by atomic adsorption spectrophotometry (AA) and ion chromatography (IC).

The second part included sampling at selected sites along the stream to quantify the arrival and departure of NaCl. These samples set the hydrologic framework by giving residence time between sites, discharge at each site, stream cross-sectional area, and other parameters needed for the transport model. This sampling continued for 2 days prior to the synoptic sampling and one day after the synoptic sampling to give time for the alluvial tracer to reach the stream and to help define the hyporheic zone. These samples were filtered on site through 0.45-micrometer ( $\mu\text{m}$ ) membrane filters.

## **SYNOPTIC SAMPLING**

During the NaCl injection, detailed geochemical samples were taken to develop mass-loading profiles. Both filtered and unfiltered samples were collected. Filtered samples were passed through a 0.45- $\mu\text{m}$  filter to determine "operationally-defined" dissolved metals. Total recoverable metals were determined from unfiltered samples.

## **ANALYTICAL METHODS**

Anions were analyzed in the 0.45- $\mu$ m filtered, unacidified samples by ion chromatography. These filtered, unacidified samples also were analyzed for sodium (Na) and lithium (Li) by atomic adsorption. Dissolved and total recoverable metal concentrations were determined by inductively coupled plasma-atomic emission spectrometry (ICP-AES). Filtered samples were analyzed for ferrous iron (FeII) colorimetrically. Alkalinity, total suspended solids, and total organic carbon were determined from unfiltered samples.



## **RESULTS AND DISCUSSION**

Results of the tracer sampling for well and stream sites are listed in appendices I and II. Site descriptions and field measurements for the synoptic sampling are listed in appendix III. Results of chemical determinations for the synoptic sampling are presented in appendix IV for major solutes and appendix V for filtered and total metals. Data are sorted in downstream order within groups of mainstem and inflow sites to emphasize the downstream changes.

### **TRACER INJECTION FOR THE WELLS**

#### **Slug Injection of LiCl in the Oro Shaft**

Three kilograms (kg) of LiCl were mixed into 5 liters (L) of deionized water and added to the Oro Mine shaft through 20 m of plastic tubing. After an initial peak and subsequent decrease, the concentration of Li remained elevated above background for several weeks (fig. 2a). A mine shaft relief well, MSRW-3, was sampled to detect Li or Cl from the slug injection. There was no Li detected in the collected samples, nor was there a variation in the Cl in the mine well, MSRW-3, (fig. 2b) or in the alluvial well, MW-3, (fig. 2c).

The initial decrease of Li in the Oro Shaft can best be interpreted as the dilution of Li as it mixed into the mine pool. After mixing, however, there was not a continual decrease of Li as might be expected if water from the mine pool was moving to the bedrock and the downgradient alluvium. Lithium was not detected in MSRW-3 or in any

of the stream samples. Thus, the simplest explanation of the trend of Cl is that the mine pool, at least the top of the mine pool in this shaft, was hydraulically isolated from the ground-water system that supplies metal-rich water to the bedrock and the alluvium. Even though there was no indication of pathway from the mine pool to the stream, this information is important to refine the conceptual model of the hydrologic system affecting the stream. The mine drainage affecting the stream must be from lower levels of the mine.

#### Slug Injection of NaBr in well MW-9

One kg of NaBr was mixed into 3 liters (L) of deionized water and poured inside the well casing of well MW-9 at 09:38 on 23Jul. The NaBr tracer dispersed over a period of 24 hours (fig. 3). Despite the high concentration of Br in well MW-9, there was no Br observed in samples from the downgradient alluvial well (MW-3) or from the stream at any of the sampling sites.

There are three possible reasons why Br did not arrive in the downgradient alluvial well or in the stream. First, for the alluvial well, there was no certainty that the downgradient alluvial well was along a potential flow path for the Br traveling in the alluvial aquifer. Second, the Br also could have been diluted below detection limits by the time it arrived at either the well or the stream. Third, for both the well and the stream, the travel time could have been greater than the time allotted for sampling. Additional samples during the following months, however, did not indicate Br in either the well or the stream. It is most likely that the sampling was not along the right flow path, and that there needed to be more Br put into the well MW-9.

## **TRACER INJECTION IN THE STREAM**

The tracer injection for the stream was prepared by adding 400 kg of NaCl to 440 L of streamwater in a 3-m diameter wading pool. This tracer was to be pumped into the stream at a rate that would maintain a constant Cl concentration of a few mg/L. After mixing the solution, however, the wading pool had a leak. Because of this leak, some of the NaCl solution was reaching the stream before the injection actually began, resulting in Cl concentrations slightly greater than normal background values (fig. 4a). Additional salt solution had to be added to the pool periodically during the 4 days of the injection to compensate for the loss and to avoid a premature end of the injection. These unplanned additions resulted in greater variability in the Cl profiles in the stream than otherwise would have been observed (fig. 4a). Chloride concentrations at stream sites are listed in appendix II.

The tracer injection can be divided into three periods (fig. 4a). The first period was the arrival of the tracer. Next, there was a plateau period where the Cl concentration should be constant at a given point downstream. Differences in tracer concentrations during this period generally are an indication of differing discharges; decreasing concentrations indicate increasing discharge from inflows of water to the stream. This leads to an accurate discharge at any given site along the stream for the synoptic samples. Because of the periodic additions of salt to the injection pool, the plateau period in French Gulch had some substantial variation. By sampling the salt solution being pumped to the stream and monitoring the pump rate, the mass balance of salt and the discharge in the stream could still be determined regardless of the variation. Finally, there was a departure

period. Along with the arrival period, the departure gives information on the residence time of solutes between the sample sites.

### Time of travel

The arrival and departure periods can be used to calculate the travel time between sites (fig. 4a). Despite the complications due to the leaky pool, the arrival times of the tracer at the downstream sites were not affected. The injection began at 09:00 hours on 24Jul and ran until 09:00 on 27Jul. The time of arrival at a site is defined as the time at which the instream tracer concentration reaches half of the plateau concentration (Zellweger and others, 1988). Arrival times are listed in table 2 with the plateau concentrations, travel time between sites, and the cumulative travel time downstream.

**Table 2—Instream chloride concentrations and travel times from the tracer-injection study.**

[C<sub>50</sub>, half plateau concentration; T<sub>50</sub>, arrival time for the C<sub>50</sub> concentration; m, meters; mg/L, milligrams per liter; <, less than.]

Site—Distance downstream	Pre-injection concentration, in mg/L	Plateau concentration, in mg/L	C <sub>50</sub> , in mg/L	T <sub>50</sub> , in hours	Time between sites, in minutes	Cumulative time, in minutes
T1—0 m	0.09	1.30	0.7	> 09:00	< 2	2
T2—516 m	.08	1.67	.87	09:23	23	23
T3—799 m	.76	1.21	.99	10:59	96	119
T4—1,161 m	.84	1.48	1.16	11:38	39	158
T5—1,651 m	.86	1.58	1.22	12:10	32	190
T6—2,536 m	.63	1.08	.86	14:00	110	300

Results of this tracer injection study indicate peculiar hydrologic characteristics of the streamflow in French Gulch (fig. 4b). First, there was a significant difference in the pre-injection concentrations of Cl between sites T2 and T3. This was mostly due to the leaky pool, and indicates that the majority of Cl entering the stream entered the hyporheic zone before reaching site T2. The increase of Cl between sites T2 and T3 indicated the return of some streamwater in the area where the 11-10 fault crosses French Gulch (fig. 1). The streamflow almost completely disappeared between sites T2 and T3 and then rejoined the stream just upstream from site T3. This also corresponded with the location of the 11-10 fault. There were several inflows with Cl concentrations substantially higher than instream concentrations, all on the right bank. Second, there was a contrast between the sharp tracer arrival at T2 and the broad, gradual arrival at T3 and T4. This difference in the shape of the breakthrough curve indicated the large amount of transient storage, or flow through the hyporheic zone, between sites T2 and T3. In a stream where mining operations have dredged almost the entire reach the path of streamflow is complex.

#### Discharge profile of the stream

An evaluation of mass loading along the stream requires an accurate discharge measurement at each sampling site, but two characteristics of the streamflow made the calculation of discharge difficult. First, there are losing reaches. Tracer-dilution methods can quantify gains, but not losses of discharge. Once a tracer has mixed into the stream water, the loss of water does not change the concentration of tracer in the remaining water. For example, between 84 m and 631 m, almost all of the surface flow in French Gulch disappeared into the alluvium, but there was no significant change in the Cl

concentration (fig. 5). Just downstream from 631 m, there was a large inflow of water upstream from the Country Boy Mine road, causing the instream tracer concentration to decrease from 3.3 to 0.4 mg/L between 631 and 744 m. Second, the Cl concentrations of inflows between 744 and 799 m exceeded the instream concentrations. This caused a sharp increase of Cl concentration from 744 to 799 m, and a gradual increase all the way to 1,161 m. These characteristics of flow in French Gulch required that we use an independent measure of discharge to prepare a discharge profile for the stream.

#### Spot injection for discharge at selected sites

In anticipation of these difficulties, spot injections gave instantaneous discharge measurements at sites T1 through T6. Spot injections required the addition of enough NaCl tracer to the stream to cause the Cl concentration to increase above the concentration of the background Cl injection (fig. 6a). The reach with the increased tracer concentration was sampled at a point about 20 m downstream from the spot injection for about an hour. The spot injection raised the Cl concentration above the level of the continuous injection upstream. These injections proved to be the key to calculating discharge over certain subreaches of the stream. At site T1, mixing of the tracer into the stream was poor, causing a large over calculation of discharge (fig. 6b). The spot injections corresponded well to discharge measurements made with a flow meter at sites T2 and T3. At sites T4 and T6, the calculated discharge from the tracer injection is about 30 percent greater than the discharge measured with a flow meter. This result is expected in mountain streams with cobble bottoms where a large percentage of the streamflow can be within the cobbles of the streambed where it cannot be measured by a flow meter. At

T5, the tracer injection indicated less flow. There were visible losses and gains of flow all along the stream between sites T4 and T6, so the discharge could have been smaller, but there is no simple explanation of why the flow-meter measurement exceeded the tracer measurement. Despite the difference in discharge measurements at site T5, it appeared that most of the lost streamflow had recombined into the stream channel upstream from site T6. Some of the flow could move to the south arm of French Gulch and appear at site FG-46, but most of the flow was in the north arm and loads could be compared between sites T4 and T6.

By knowing discharge at each of the transient sites, it was possible to calculate discharge at intermediate sites for gaining reaches in French Gulch. Although the reach from T2 to T3 had a net gain in flow, the surface flow nearly disappeared before much of that flow was added back by large springs just upstream from T3. This pattern made it impossible to calculate discharge at intermediate sites between T2 and T3. Intermediate discharge was calculated for sampling sites between T3 and T4 by using the spot-injection discharge at T3 as the first upstream discharge and calculating the next downstream discharge with the equation:

$$Q_d = \frac{Q_u(C_u - C_i)}{(C_d - C_i)}$$

where  $Q_d$  is the downstream discharge,  $Q_u$  is the upstream discharge,  $C_u$  and  $C_d$  are the upstream and downstream tracer concentrations, and  $C_i$  is the concentration of tracer in the inflow. Thus, the discharge profile was well defined at intermediate points between T3 and T4, which brackets a critical reach of fault seepage. There also were good discharge

measurements for sites T2 and T6 (fig. 6c). Between sites T4 and T6, there is a small, net gain in discharge. Flow along that reach is complex, but for mass-balance calculation, this increase in discharge can be prorated by distance along the reach.

## **SYNOPTIC SAMPLING OF STREAM SITES**

Synoptic sampling sites were chosen to bracket all of the visible and likely inflow areas to French Gulch. A description of each sampling site with the temperature, pH, and conductivity measured at the sites is listed in appendix III.

### Major-ion chemistry

Upstream from the mines, the water in French Gulch was mostly a calcium bicarbonate type (see appendix IV). The calculated dissolved solids concentration at 516 m (T2) was 63 mg/L; indicating that French Gulch is a dilute headwater stream upstream from mining. Inflows from mining mostly added calcium sulfate type water, reflecting the oxidation of sulfide minerals and the release of calcium from rocks that are weathered by the increased acidity of the water. Downstream from all the mine inflows at 2,536 m (T6), the stream had changed to a calcium sulfate-magnesium carbonate type water, with dissolved solids of 124 mg/L. Thus, mining inflows caused a slight change in major ion chemistry, and a doubling of the dissolved solids.

### Metal chemistry

Oxidation of sulfide minerals, accelerated by mining in French Gulch has produced substantial concentrations of Fe, Cd, Mn, and SO<sub>4</sub> in the ground and surface water. Other



metals such as aluminum, copper, and lead occur in the streamwater of French Gulch, but generally in very low concentrations (appendix V). Upstream from the effects of mine drainage, at 516 m (T2) and farther upstream, the metal concentrations were low, often below detection. The highest metal concentrations occurred at 2,536 m (T6) which was downstream from all the metal-rich inflows. Further downstream at 2,600 m (FG42) these concentrations were diluted by the inflow from the south branch of French Gulch.

There was a large range of metal concentrations among the inflows that were sampled. The inflow at 1,701 m (FG38) had the highest concentrations for Cd, Mn, and Zn, followed by the inflow at 2,400 m (FG44). The highest concentrations of Fe were detected in samples from the inflow at 2,400 m. Both these inflows were a long distance downstream from the 11-10 and Bullhide faults. Inflows with high concentrations of metals also occurred in the area between the 11-10 and Bullhide faults at 840 m (FG15 on the right bank and FG19 on the left bank), 812 m (FG16), 814 m (FG16c), and 857 m (FG22). These metal-rich inflows occurred on both sides of the stream.

#### Downstream profiles of sulfate and metals

The  $\text{SO}_4$  and mine-related metals have similar downstream patterns of concentration (figs. 7 and 8). The occurrence and distribution of  $\text{SO}_4$  and these metals are controlled by the geologic and hydrologic setting of French Gulch.

Concentrations of  $\text{SO}_4$  in French Gulch ranged from 10.6 mg/L above the mine-affected area to 62 mg/L downstream from all the mine inflows. The variation of  $\text{SO}_4$  concentration among inflows was even greater, ranging from 10.8 to 453 mg/L. There

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were substantial increases of instream  $\text{SO}_4$  concentrations at three locations along the stream (fig. 7). The first increase occurred between 631 and 881 m, where the concentration increased to almost 21 mg/L. This was in the vicinity of the 11-10 fault (fig. 1) and was likely related to discharge from the Wellington-Oro mine. The second increase occurred between 2,080 (FG52) and 2,200 m (FG55) and the concentration increased to about 45 mg/L. This is where the north branch gained a substantial inflow of metal- and sulfate-rich water that had entered the side channel at 1,826 m (FG39b). Finally, the concentration increased to 62 mg/L between 2,388 (FG45) and 2,536 m (T6).

Each of the mine-related metals had patterns similar to  $\text{SO}_4$  (fig. 8). Filtered iron concentrations varied from less than 1  $\mu\text{g/L}$  upstream from mining to 53  $\mu\text{g/L}$  at T6 (2,536 m) below the mine-drainage inflows (fig. 8a). Iron was the most variable of the metals because iron tends to precipitate more readily than the other metals. Concentrations of filtered Cd were low, ranging from less than detection to 13  $\mu\text{g/L}$ , but indicated a very clear increase with distance downstream (fig. 8b). Unlike the other solutes, the increase of filtered Cd was not as great between 2,150 and 2,220 m. There were greater concentrations of Cd in the inflows between 819 and 840 m than in the inflows at 1,701 and 2,200 m. Filtered concentrations of Mn and Zn (figs. 8c and d) had increases at the same three locations. Concentrations of Mn and Zn were substantially greater than Fe and Cd. Concentrations of Mn ranged from near 1  $\mu\text{g/L}$  upstream of the mining inflows to near 1,000  $\mu\text{g/L}$  at T6 (2,536 m). Concentrations of filtered Zn ranged from near 10  $\mu\text{g/L}$  upstream of mining inflows to near 5,000  $\mu\text{g/L}$  at site T6. The Zn which enters the stream most likely is the principal cause of fish toxicity in French Gulch.

Mass-loading profiles

With a discharge profile, the concentration profiles compiled from spatially intensive sampling of stream sites and inflows can be converted into mass-loading profiles. Because mass-loading profiles take discharge into account, they are more useful than concentration profiles to indicate those reaches of the stream most affected by mine drainage and to evaluate the relative importance of the inflows (fig. 9). Each of the main increases can be quantified as a percentage of the most downstream load at T6. For  $\text{SO}_4$  (fig. 9a), the inflows between 516 m (T2) and 799 m (T3), accounted for 19 percent of the  $\text{SO}_4$  load. Concentrations of  $\text{SO}_4$  in these inflows were low, suggesting that they were not affected by mining. The  $\text{SO}_4$ -rich inflows between 799 and 1,161 m (T4) are likely related to the 11-10 and Bullhide faults, and accounted for 16 percent of the load. Sixty-four percent of the load entered over the last, broad subreach from 1,161 to 2,536 m (T6). The major increases in load likely occurred where the stream gained  $\text{SO}_4$  at 2,150 and 2,220 m, from surface drainage of the Bullhide Fault. These final inflows to the north branch are the most significant for adding  $\text{SO}_4$ .

The mass loadings of Mn and Zn were similar to  $\text{SO}_4$  (figs. 9b and 9c). The first major inflow between T3 (799 m) and T4 (1,161 m) accounted for 26 percent of the Mn and about 32 percent of the Zn. The remainder of the Mn and Zn loads entered the north branch with the inflows at 2,150 and 2,400 m, both of which drain flow from the Bullhide Fault.

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A different accounting of load occurred for Cd (fig. 9d). Essentially none of the Cd load was added upstream from T3 (799 m). Between T3 and T4 (1,161 m), however, 66 percent of the downstream load was added, suggesting the importance of the 11-10 and Bullhide faults. Thirty-four percent of the load entered between T4 and T6 (2,536 m). This loading could be proportionally smaller than the loading for Mn and Zn because Cd could be sorbed onto the abundant Fe oxides that line the bottoms of stream channels where water flows from the Bullhide Fault to inflows at 1,826, 2,400, and 2,422 m.

Between T3 and T4, the individual inflows have different effects on the mass loading in each stream segment (fig. 10). For example, the inflows in the first two segments, from 799 to 825 m and then from 825 to 881 m, caused the instream Zn concentration to increase from 48 to 368  $\mu\text{g/L}$  and then to 700  $\mu\text{g/L}$ . However, from 881 to 981 m there were no visible surface inflows and yet the concentration of Zn increased more than 2-fold to 1,570  $\mu\text{g/L}$ . The likely cause of the large increase was discharge from the Bullhide Fault, which crosses the stream in that segment. Over the next two segments, from 981 to 1,087 m and then to 1,161 m, there were again no visible surface inflows and the Zn concentration did not increase. Sulfate, Cd, and Mn all increase in this same detailed pattern, suggesting that discharge from the Bullhide Fault contributes substantially to the instream loads.

## **IN-STREAM PROCESSES AFFECTING METAL TRANSPORT**

Differences between the total recoverable and dissolved concentrations of Fe indicated that the majority of Fe transport was by Fe-rich colloidal particles (fig. 11).

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Colloids have been shown to have a role in metal transport of other Rocky Mountain streams affected by mine drainage (Kimball and others, 1992; Kimball and others, 1995; Broshears and others, 1996). Iron-colloids are not toxic unless other metals are sorbed to them. It appears that very little of the Zn was transported by the Fe colloids (fig. 11b), but other metals like Cd and Cu generally are associated with Fe colloids (Kimball and others, 1992, table 3). Although a separate study will address the definition of colloidal transport in French Gulch (Kimball, unpublished data), these data indicate that colloidal transport can influence the occurrence and distribution of metals downstream from the mine drainage.

## CONCLUSIONS

Metals in the streamwater of French Gulch originate from drainage of old mines in the watershed and enter the stream in a complex pattern. A LiCl tracer injection into the Oro Shaft of the Wellington-Oro Mine did not indicate pathways from the upper levels of the mine to the alluvium and the stream. The persistence of the LiCl tracer in the upper portion of the Oro Shaft suggested that there was little hydrologic connection with the ground water feeding the alluvium and affecting the stream. The NaBr injection into an alluvial well was attenuated by ground-water flow in the alluvium, but Br was not detected in the downgradient alluvial well or in the stream. Using a NaCl tracer injection and synoptic sampling, the downstream profile of metal concentrations and mass loading indicates those subreaches of French Gulch where the majority of metal loading occurs. There is substantial inflow of metals where the Bullhide Fault crosses the stream. The majority of metal load enters French Gulch downstream from those faults at points where, by inference, surface drainage from the Bullhide Fault enters the north branch. The major inflows come from springs that are affected by the Wellington-Oro Mine on the north side of French Gulch. Some of the metal transport is by colloidal Fe-oxides, but the extent of that transport needs to be defined in further studies. The patterns of loading indicate the important influence of the geologic structure on instream metal concentrations and that the stream is mostly affected by drainage of the mine pool by faults.

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**APPENDICIES**

**Appendix I—Concentration of lithium, bromide, and chloride in wells.**

**Appendix II—Concentration of chloride in the stream and tributaries.**

**Appendix III—Site descriptions and field measurements of synoptic sampling sites.**

**Appendix IV—Concentrations of major ions in synoptic samples.**

**Appendix V—Concentrations of metals in synoptic samples.**

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### Appendix III—Site descriptions and field measurements of synoptic sampling sites.

[SiteID; field identification label; Dist; distance downstream from injection, in meters; Temp, temperature, in degrees Celsius; pH, in log units; Cond, conductivity, in microsiemens per centimeter at 25 degrees; Q, discharge from tracer calculations, in liters per second; Qmeter, discharge from flow-meter measurement, in liters per second; RB, right bank; LB, left bank.]

SiteID	Dist	Description of site	Temp	pH	Cond	Q	Qmeter
<i>Stream sites</i>							
FG00	0	Injection point	10.5	8.23	84		136.0
FG03	84	Along straight portion of stream	11.0	8.16	101		
FG05	234	Along straight portion of stream	11.0	8.19	98		
TS02	516	Site T2 (State site FG5)	11.0	7.82	98	74.2	93.4
FG09	631	Flag on RB at downstream end of willows, channel is about 35 ft wide	11.5	8.08	100		
FG09d	744	End of culvert at Country Boy road	5.5	8.17	109		
TS03	799	Site T3; stream at top of cascade; ISCO site	7.0	7.96	108	304.0	328.0
FG17b	825	Stream site added to see effect of FG16-b&c; distance estimated	7.0	7.81	112	334.6	
FG18	881	Stream; at bottom of steep rock hill	8.0	8.06	131	354.0	
FG25	981	Old FG25 was inflow that is now dry; this is stream site to replace FG24	9.0	7.74	136	368.0	
FG28	1,087	Stream -near white semi trailer	7.0	7.71	135	375.0	
TS04	1,161	Site T4; stream below culvert; ISCO site	7.0	7.74	135	372.0	279.0
FG31	1,242	By big cut in alluvium with foot bridge (pole across stream)	7.0	7.53	138		
FG33	1,356	Downstream from 3 pole power tower	8.0	7.70	137		
FG35	1,515	Before double power poles	7.5	7.61	135		
TS05	1,651	Site T5; below inflow area; ISCO Site	10.0	7.35	138	179.7	334.0
FG39	1,751	Above split of North Branch to ponded area	9.0	7.17	192		
FG50	1,880	Wide gravel bar; north branch, first site downstream from FG39	8.5	7.27	137		
FG52	2,080	Open area after bend	11.0	7.26	128		
FG53	2,150	Narrow channel above confluence with re-emergent flow from FG41	9.0	7.19	132		
FG55	2,200	Below FG53/54 confluence	8.0	7.32	184		
FG45	2,388	Open area 100m upstream from triple power pole; Upstream from dirty inflow	7.5	7.28	170		
TS06	2,536	Site T6 (State FG7 site) downstream from inflow of acid drainage	7.5	7.38	214	376.6	297.0
FG46	2,540	South arm inflow to Dead Elk pond (State site FG8)	7.0	7.28	122		

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SitelD	Dist	Description of site	Temp	pH	Cond	Q	Qmeter
FG42	2,600	Culvert at the end of Dead Elk pond; farthest downstream point	8.0	7.31	139		
<i>Inflow sites</i>							
FG06	333	LB water exits from rocks all the way over to the dredge pile	8.5	8.05	97		
FG09b	694	LB water exits from rocks	6.0	8.15	95		
FG09c	695	RB water exits from rocks	7.0	7.90	117		
FG10	745	LB water exits from rocks- downstream end of culvert @ Country Boy mine	6.5	8.50	102		
FG12	769	RB Another inflow; large flow from rocks	6.5	8.05	100		
FG13	784	RB Third inflow RB 20 feet downstream again	8.0	8.04	101		
FG16	812	Inflow LB along cascade section		7.62	266		
FG16b	813	RB inflow - Mine water	8.0	7.77	135		
FG16c	814	RB inflow - Mine water	8.0	7.78	144		
FG19	840	LB Inflow	6.0	7.53	306		
FG15	840	RB pool w/ yellow boy; downstream from FG-16	8.0	7.27	292		
FG22	857	LB	10.0	8.09	444		
FG27	1,073	LB Inflow near double tower; ~10m L of stream	17.5	7.87	366		
FG32	1,266	RB just around bend, about 3m	6.5	7.72	135		
FG36b	1,605	Inflow added 7/24/96, never makes it to the stream - parallels stream	6.5	7.60	144		
FG38	1,701	Inflow RB spring at base of dredge pile; water coming in all along base of	5.0	6.63	860		
FG51	1,980	Drainage from spring FG-6; re-enters split off branch after pond	7.5	7.34	137		
FG54	2,150	Re-emergent water from FG41 area	7.5	7.19	206		
FG44	2,400	Mine drainage, dirty inflow RB; - sample near rd instead of by stream	7.0	7.01	412		
FG56	2,422	FG44 and water from the base of rubble where it joins stream	8.0	6.97	280		
<i>Bullhide Fault surface drainage</i>							
FG39b	1,826	RB inflow below pond; Orange suggests it differs from water out of pond	9.0	7.33	262		
FG40	1,869	North branch beyond pond; water leaving channel at this point	9.0	7.38	251		
FG41	1,920	Point where all the water goes under the rocks (drain from pond only)	9.0	7.30	244		

# Appendix IV—Concentrations of major ions in synoptic samples.

[Dist, distance downstream from injection site, in meters; SiteID, field sample and flag identifier; concentrations are in milligrams per liter.]

Dist	SiteID	Calcium	Magnesium	Sodium	Potassium	Chloride	Sulfate	Bicarbonate
Stream samples								
0	FG00	17.8	1.43	1.3		0.1	10.6	39.4
84	FG03	17.9	1.42	4.0		3.4	10.6	39.9
234	FG05	18.6	1.47	4.2		3.4	10.6	40.4
516	TS02	17.5	1.40	3.6		3.3	10.6	40.2
631	FG09	17.7	1.42	3.6		3.3	10.6	39.4
744	FG09d	22.1	1.93	1.5		0.4	15.3	47.9
799	TS03	22.0	1.92	2.0		1.0	14.3	45.4
825	FG17b	21.1	1.95	2.0		1.1	15.1	44.8
881	FG18	23.2	2.49	2.0	2.0	1.1	20.6	47.2
981	FG25	23.0	2.62	2.0		1.2	21.5	45.1
1,087	FG28	23.2	2.62	2.0		1.3	21.9	45.7
1,161	TS04	22.6	2.54	2.0		1.2	22.5	45.3
1,242	FG31	23.2	2.60	2.0		1.2	23.6	45.6
1,356	FG33	22.8	2.55	2.0		1.2	23.5	45.1
1,515	FG35	23.2	2.59	2.0		1.2	21.5	44.8
1,651	TS05	22.7	2.54	2.0		1.2	23.1	46.2
1,751	FG39	28.0	4.01	2.0		1.1	46.7	43.5
1,880	FG50	21.8	2.47	1.9		1.2	21.6	45.1
2,080	FG52	23.0	2.60	2.0		1.2	21.6	45.8
2,150	FG53	22.7	2.60	2.0		1.1	24.4	45.0
2,200	FG55	28.2	4.08	2.1		1.2	44.6	42.0
2,388	FG45	26.5	3.90	2.0		1.1	46.3	42.5
2,536	TS06	30.1	5.00	2.1		1.1	62.0	40.4
2,540	FG46	21.3	2.63	1.6	1.0	0.8	25.7	39.1
2,600	FG42	26.8	4.19	1.9		1.1	53.4	39.9
Inflow samples								
333	FG06	18.3	1.44	3.4		3.1	10.8	39.1
694	FG09b	19.4	1.71	1.3		0.2	12.8	42.9
695	FG09c	22.8	1.98	1.8		0.9	16.2	48.5
745	FG10	20.0	1.74	1.6		0.7	12.7	44.8
769	FG12	18.4	1.50	2.9		2.6	11.3	39.8
784	FG13	20.0	1.65	2.7		2.4	12.6	40.9
812	FG16	39.4	7.75	1.6		0.3	76.6	52.3
813	FG16b	23.1	2.39	2.5		2.2	23.2	41.6
814	FG16c	23.2	2.72	2.7		2.4	26.2	40.3
840	FG19	43.2	8.95	1.6		0.4	86.7	56.9
840	FG15	33.1	8.07	2.5		2.1	95.6	36.0

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Dist	SiteID	Calcium	Magnesium	Sodium	Potassium	Chloride	Sulfate	Bicarbonate
Inflow samples—continued.								
857	FG22	72.6	14.23	2.0	2.0	0.4	103.5	124.0
1,073	FG27	63.8	6.07	3.4		0.3	59.9	119.0
1,266	FG32	23.3	2.57	2.0		1.1	23.2	43.4
1,605	FG36b	24.7	2.94	1.7		0.9	29.3	43.1
1,701	FG38	107.0	29.55	3.7	2.0	1.5	453.0	26.3
1,980	FG51	22.7	2.53	1.4		0.9	23.2	41.1
2,150	FG54	30.0	4.68	2.0		1.1	60.7	39.9
2,400	FG44	52.8	12.15	2.7		1.4	176.2	29.6
2,422	FG56	39.3	7.72	2.5	1.0	1.2	97.2	37.5
Bullhide Fault surface flow								
1,826	FG39b	36.1	6.26	2.2		1.2	76.7	39.6
1,869	FG40	35.5	5.97	2.2		1.2	76.4	40.4
1,920	FG41	34.8	5.72	2.2	1.0	1.2	67.3	41.3

### Appendix V—Concentrations of metals in synoptic samples.

[Dist, distance downstream from injection site, in meters; SiteID, field sample and flag identifier; -d, dissolved concentration, in micrograms per liter; -t, total recoverable concentration, in micrograms per liter; Al, aluminum; Cd, cadmium; Cu, copper; Fe, iron; Mn, manganese; Pb, lead; Zn, zinc. Blank entries indicate concentrations below detection limits.]

Dist (m)	SiteID	Al-d	Al-t	Cd-d	Cd-t	Cu-d	Cu-t	Fe-d	Fe-t	Mn-d	Mn-t	Pb-d	Pb-t	Zn-d	Zn-t
Stream samples															
0	FG00		55.0						74.9	3.0	6.0		1.0	8.5	10.2
84	FG03								19.9	2.0	4.0		1.0	7.3	8.1
234	FG05							8.0	24.3	2.0	4.0			9.3	10.6
516	TS02								24.9	1.0	2.0		1.0	15.5	14.8
631	FG09								23.0	2.0	4.0		1.0	14.1	17.4
744	FG09d								6.4					10.2	11.2
799	TS03		62.0		1.0				69.9		4.0		2.0	47.8	50.5
825	FG17b		63.0	2.0	2.0		1.0	6.0	82.0	60.0	67.0		2.0	368.2	372.0
881	FG18		72.0	4.0	4.0			6.0	64.9	111.0	119.0		2.0	699.2	703.7
981	FG25		69.0	8.0	8.0			13.0	88.2	302.0	320.0			1,571.9	1,570.6
1,087	FG28		81.0	8.0	8.0		2.0	13.0	80.7	305.0	314.0			1,587.8	1,546.8
1,161	TS04		57.0	8.0	8.0			9.0	93.6	289.0	313.0			1,515.1	1,556.8
1,242	FG31		68.0	8.0	8.0			16.0	82.2	292.0	307.0		1.0	1,543.7	1,565.6
1,356	FG33		55.0	8.0	8.0		1.0	11.0	79.9	281.0	308.0			1,480.4	1,572.9
1,515	FG35		48.0	7.0	8.0			11.0	64.5	285.0	299.0			1,502.5	1,521.4
1,651	TS05			7.0	8.0			23.0	58.2	271.0	291.0			1,428.6	1,486.4
1,751	FG39	76.0	55.0	11.0	12.0	2.0	1.0	34.0	77.9	809.0	851.0		1.0	3,184.7	3,242.0
1,880	FG50		66.0	7.0	8.0	1.0	2.0	11.0	40.1	243.0	266.0		1.0	1,335.1	1,417.4
2,080	FG52		43.0	7.0	8.0		1.0	6.0	44.7	249.0	270.0		1.0	1,360.3	1,431.7
2,150	FG53		77.0	7.0	8.0			19.0	51.8	237.0	254.0		1.0	1,349.2	1,407.0
2,200	FG55		40.0	10.0	12.0			36.0	114.1	631.0	667.0	1.0	3.0	2,976.1	3,055.0
2,388	FG45	40.0		9.0	11.0			26.0	117.9	603.0	617.0	1.0	3.0	2,882.6	3,015.9
2,536	TS06	43.0		12.0	12.0	2.0	2.0	53.0	204.3	1,091.0	1,121.0		5.0	4,511.0	4,741.5

Dist (m)	SiteID	Al-d	Al-t	Cd-d	Cd-t	Cu-d	Cu-t	Fe-d	Fe-t	Mn-d	Mn-t	Pb-d	Pb-t	Zn-d	Zn-t
Stream samples—continued.															
2,540	FG46	44.0		3.0	4.0				61.2	14.0	18.0		2.0	646.7	701.8
2,600	FG42			9.0	10.0			32.0	134.2	763.0	788.0		3.0	3,357.9	3,548.2
Inflow samples															
333	FG06								26.8		2.0		1.0	13.6	14.8
530	MW9			1.0	9.0										
694	FG09b								8.2					8.1	11.2
695	FG09c								39.8		2.0		1.0	16.9	17.0
745	FG10		119.0		1.0				136.2		7.0		3.0	37.2	58.5
769	FG12			0.0	1.0	1.0		7.0	48.4		4.0		1.0	76.2	79.8
784	FG13		127.0	1.0	1.0				182.8		15.0		5.0	121.5	135.4
812	FG16			20.0	18.0				38.8	5.0	8.0			5,414.5	5,085.0
813	FG16b			2.0	2.0			61.0	114.6	297.0	311.0			641.2	637.1
814	FG16c			10.0	11.0	1.0	3.0	60.0	121.9	466.0	458.0			2,137.8	2,001.8
840	FG19			21.0	20.0			10.0	15.8	3.0	4.0		1.0	5,616.1	5,549.0
840	FG15		278.0	76.0	76.0	4.0	8.0	55.0	637.0	3,482.0	3,449.0		3.0	16,335.0	15,810.
857	FG22			3.0	3.0					92.0	97.0			2,024.4	2,002.4
1,073	FG27							31.0	277.2	134.0	183.0			7.3	10.8
1,266	FG32		210.0	5.0	6.0				183.4	12.0	37.0		2.0	1,044.1	1,098.2
1,605	FG36b			4.0	5.0			9.0	13.9	13.0	14.0			737.2	750.2
1,701	FG38	58.0	58.0	121.0	130.0	13.0	14.0	182.0	200.9	15,340.0	17,078.0	24.0	21.0	43,917.0	47,248.
1,980	FG51			3.0	4.0			12.0	20.7	12.0	14.0			470.4	486.7
2,150	FG54		131.0	12.0	13.0	1.0	1.0	48.0	154.5	832.0	922.0	2.0	5.0	3,744.7	3,991.0
2,400	FG44			25.0	31.0			178.0	1028.	5,008.0	5,405.0	4.0	17.0	17,104.0	18,029.
2,422	FG56			17.0	20.0			159.0	419.6	2,365.0	2,321.0	1.0	8.0	8,636.5	8,658.3

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Dist (m)	SiteID	Al-d	Al-t	Cd-d	Cd-t	Cu-d	Cu-t	Fe-d	Fe-t	Mn-d	Mn-t	Pb-d	Pb-t	Zn-d	Zn-t
Bullhide Fault surface flow															
1,826	FG39b			16.0	17.0		2.0	428.0	928.9	1,511.0	1,598.0		14.0	5,934.9	6,146.1
1,869	FG40			14.0	13.0		1.0	196.0	427.1	1,466.0	1,515.0		6.0	5,395.7	5,400.0
1,920	FG41		54.0	13.0	14.0			122.0	373.6	1,307.0	1,357.0	1.0	6.0	4,908.7	4,956.0



**LIST OF FIGURES**

**Figure 1—Location of surface- and ground-water sampling sites along French Gulch, indicating important geologic features.**

**Figure 2—Variation of (a) lithium in the Oro Shaft, (b) chloride in the mine-relief well MSRW-3, and (c) chloride in the alluvial well MW-3.**

**Figure 3—Bromide versus time at well MW-9, site of the NaBr slug injection.**

**Figure 4—Chloride concentration history for (a) site T4 for the entire period of injection, and (b) the arrivals at sites T2, T3, and T4.**

**Figure 5—Downstream variation of chloride concentration from the synoptic sampling.**

**Figure 6—(a) Chloride versus time at transient site 3 for spot injection, showing the rise above background tracer injection. (b) Comparison of discharge measured by spot injections of tracer with discharge measured by flow meter. (c) Discharge profile for French Gulch.**

**Figure 7—Downstream variation of instream and inflow sulfate concentrations.**

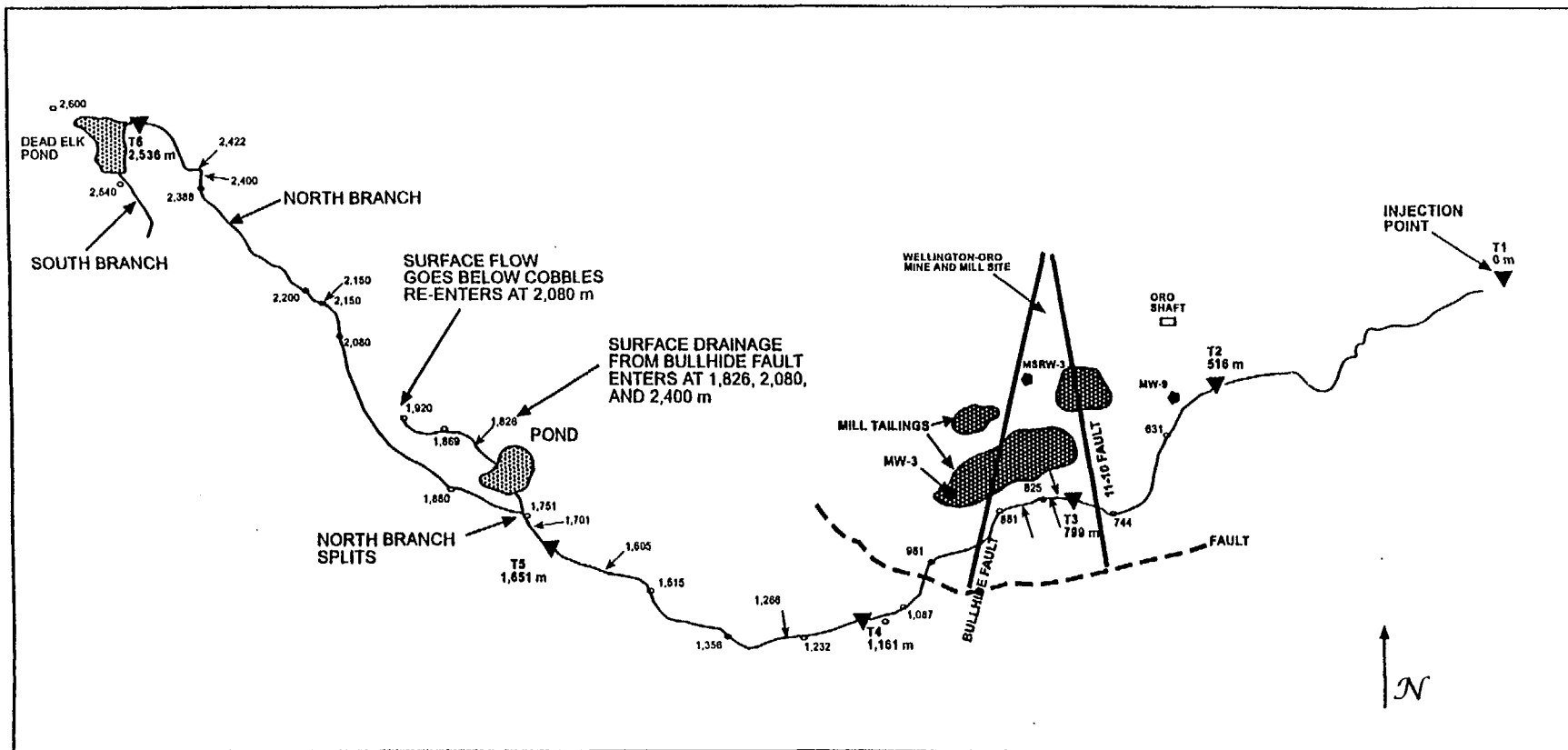
**Figure 8—Downstream variation of concentrations for (a) iron, (b) cadmium, (c) manganese, and (d) zinc.**

**Figure 9—Downstream variation of mass loading for (a) sulfate, (b) manganese (c) zinc and (d) cadmium.**

**Figure 10—Detail of zinc concentration increases between sites T3 and T4.**

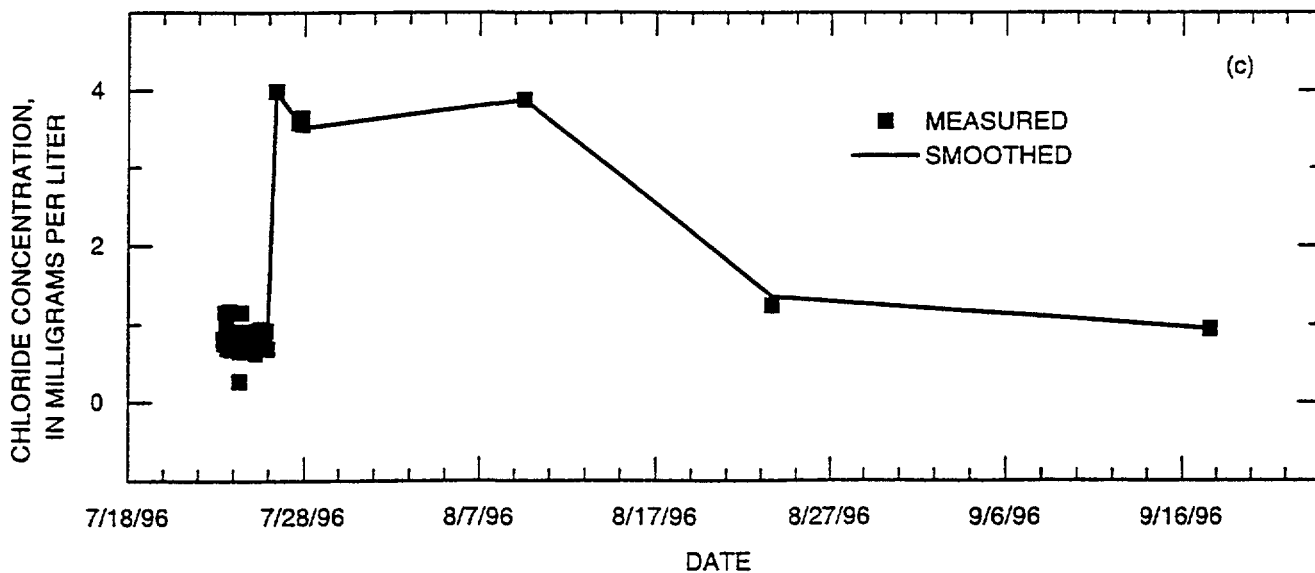
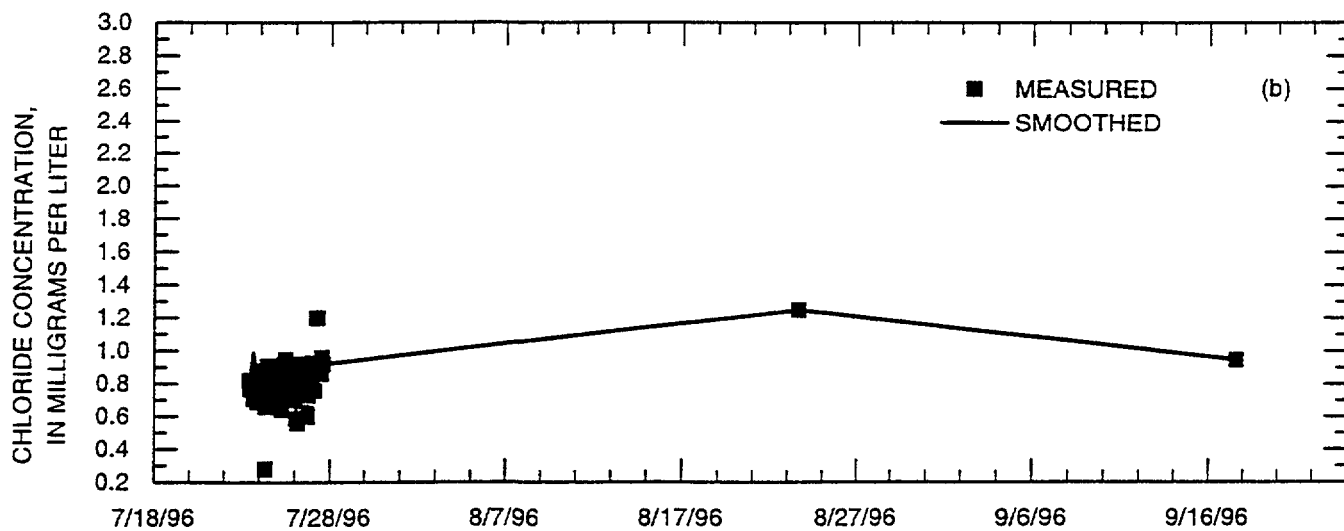
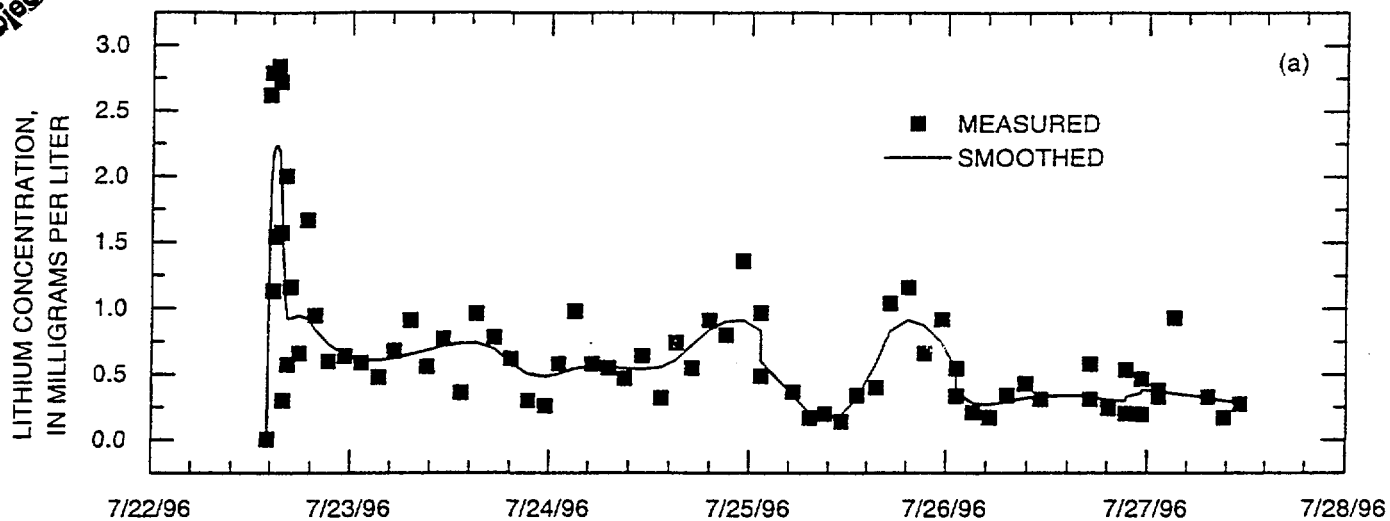
**Figure 11—Downstream profile of filtered and total concentrations of (a) iron and (b) zinc, indicating colloidal concentrations of these metals.**

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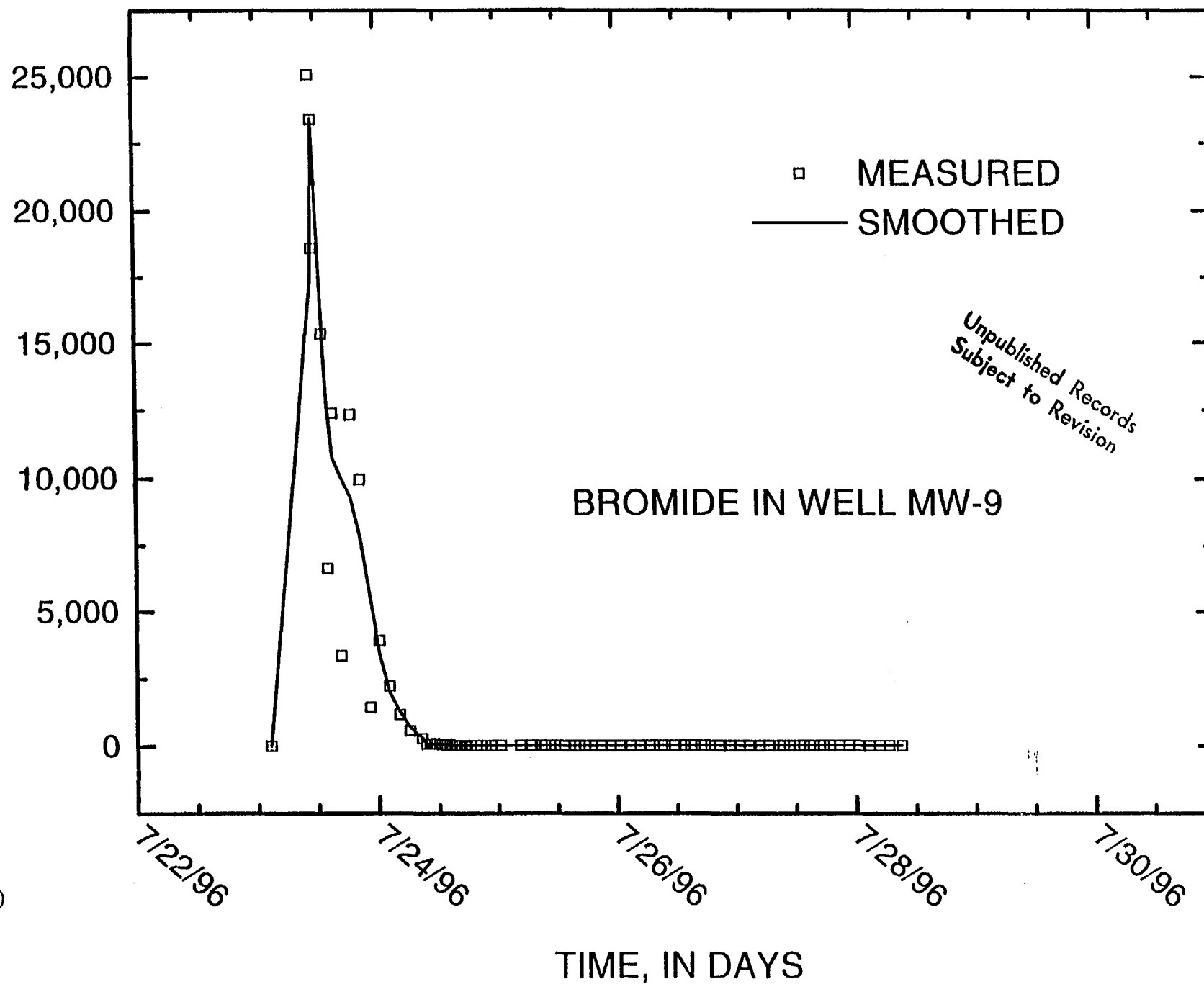
#### EXPLANATION

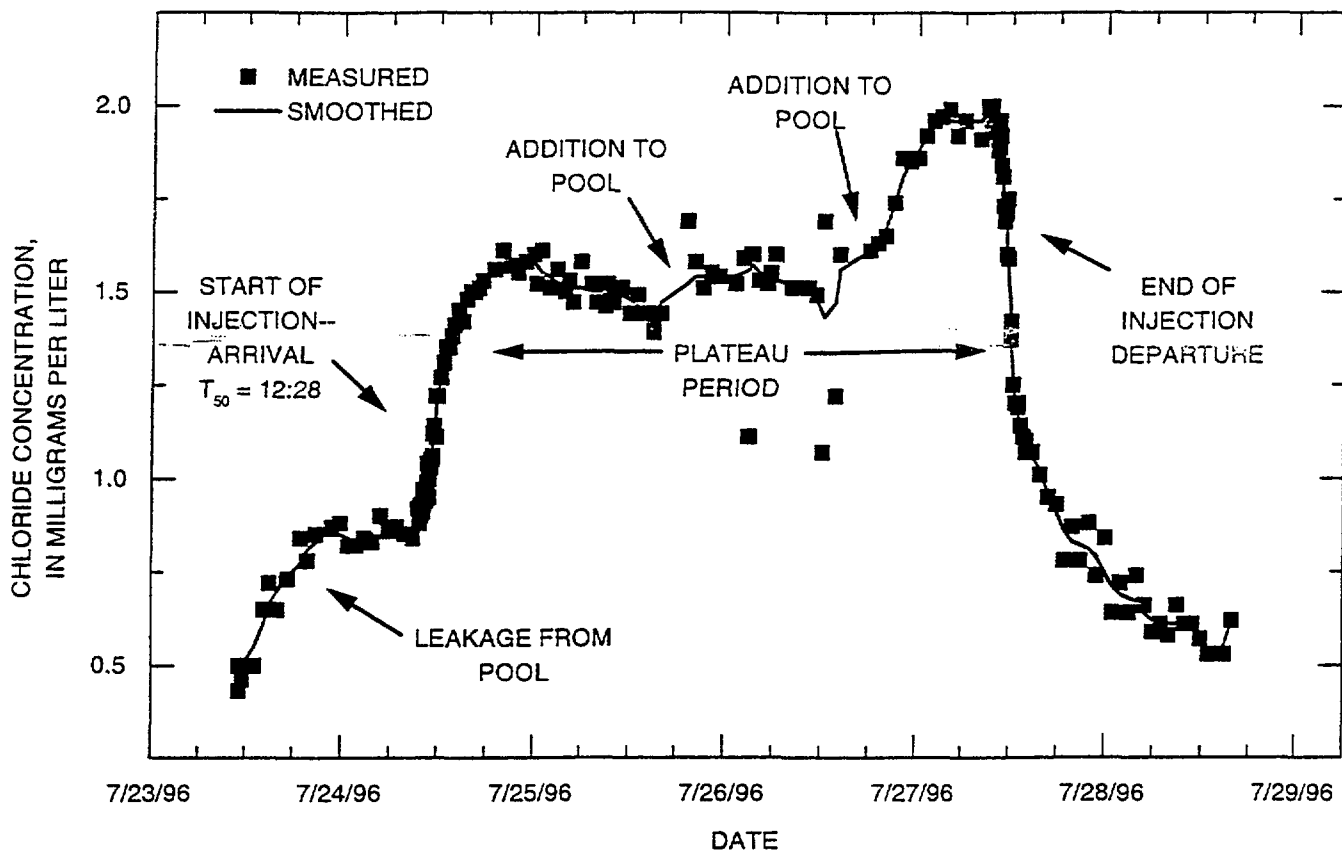
- ▼ T3 799 m TRACER SAMPLING SITE
- ◆ MW-3 GROUND-WATER MONITORING SITE
- 1,232 STREAM SAMPLING SITE
- ↓ 1,232 INFLOW SAMPLING SITE



BROMIDE CONCENTRATION,  
IN MILLIGRAMS PER LITER

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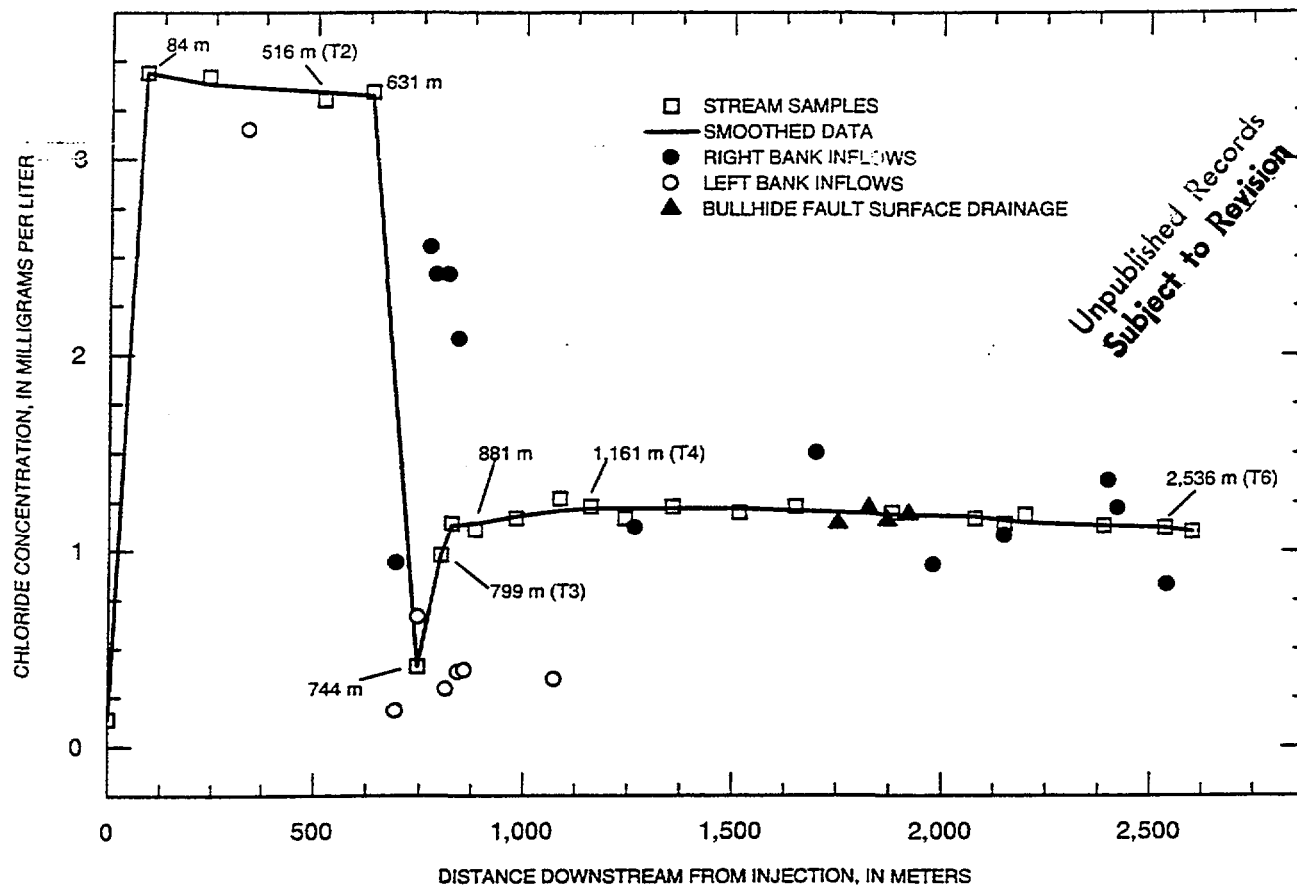
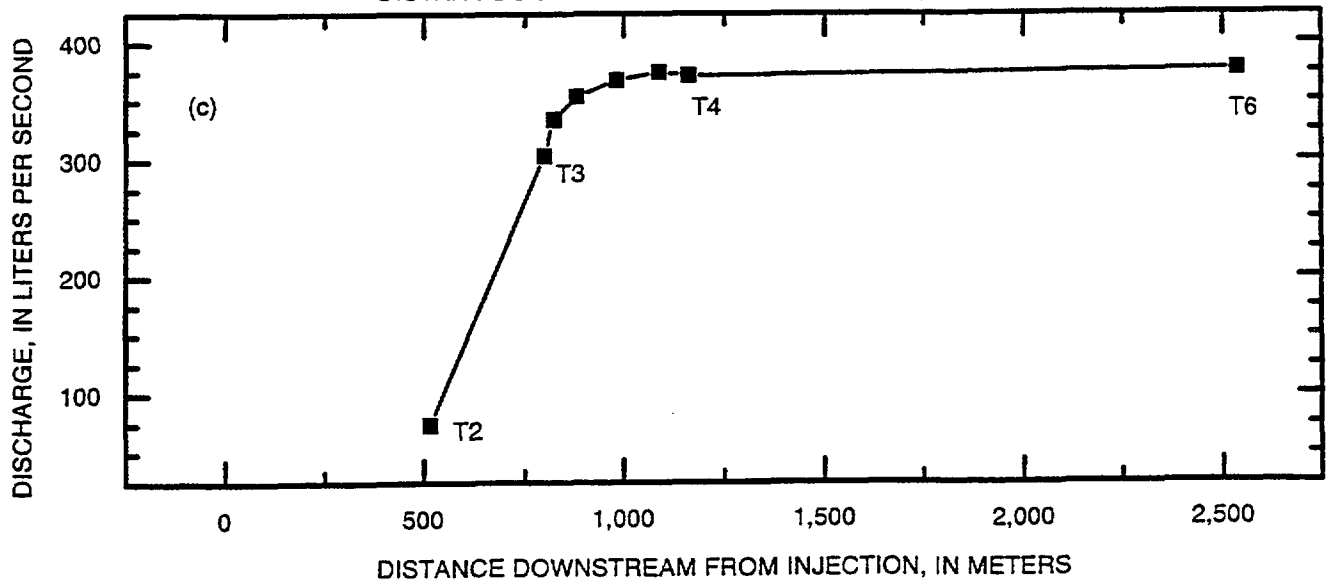
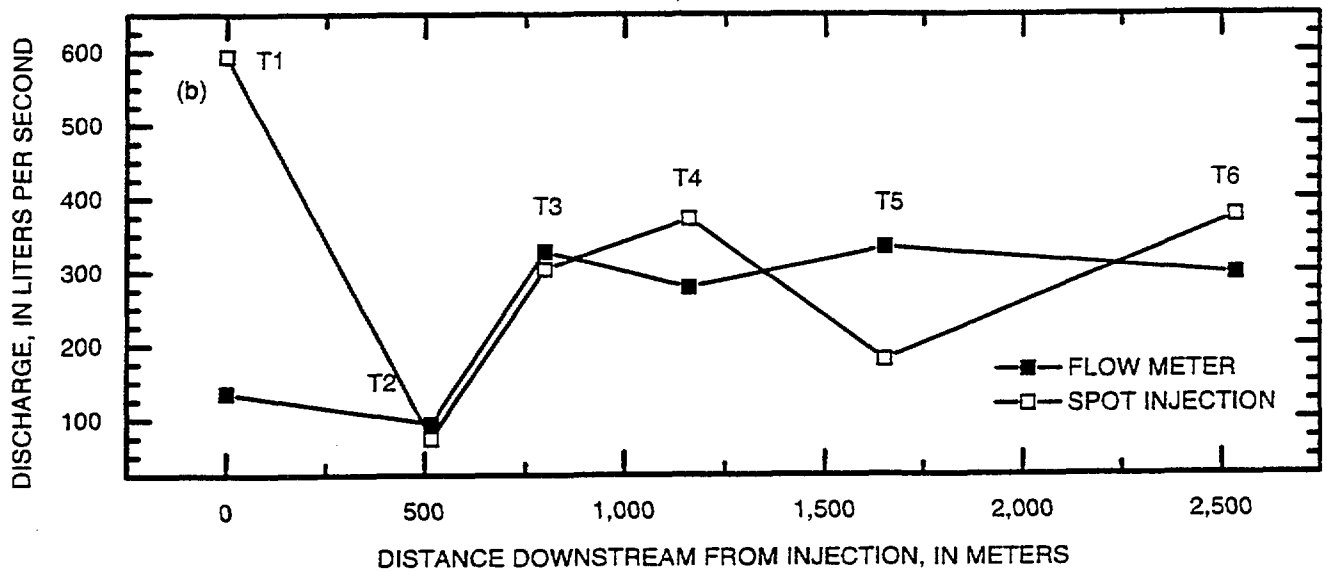
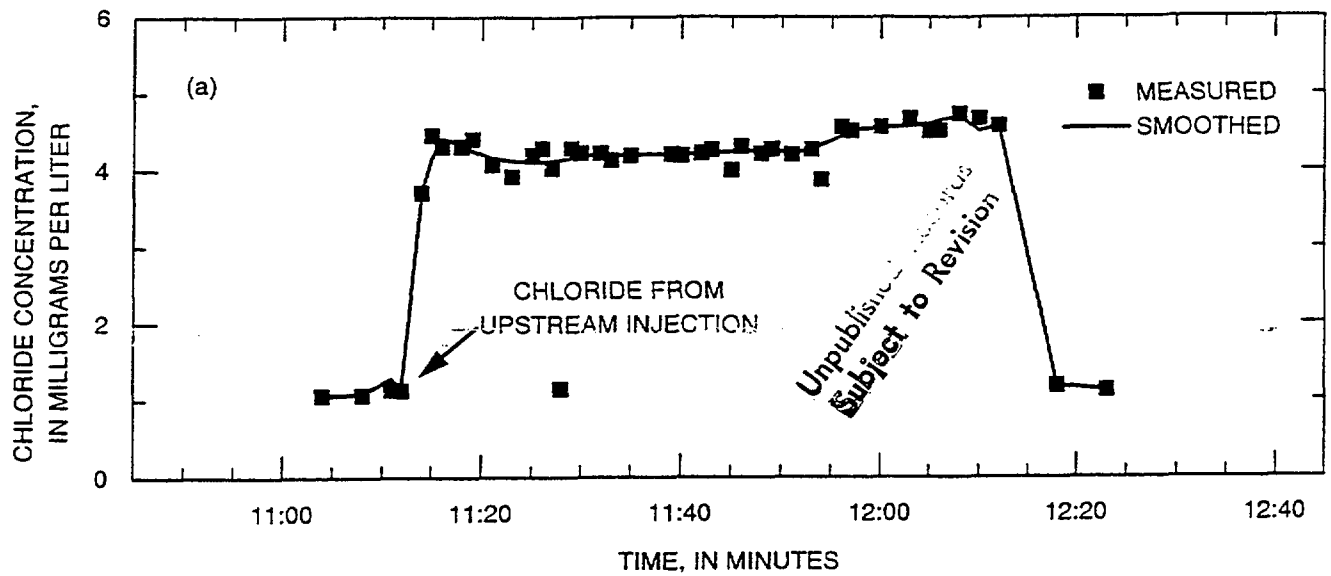


Figure 5--Downstream variation of chloride concentration from the synoptic sampling in French Gulch, Colo.





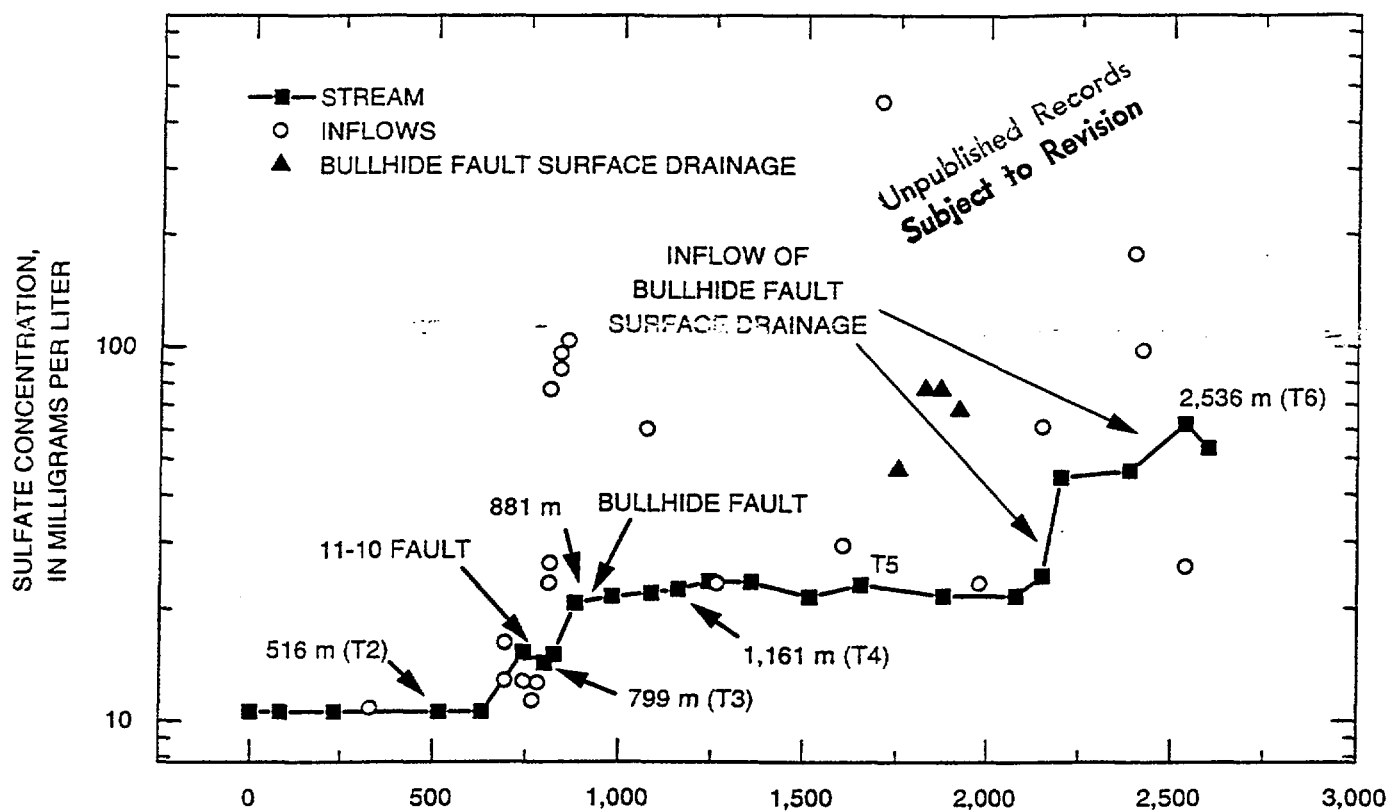
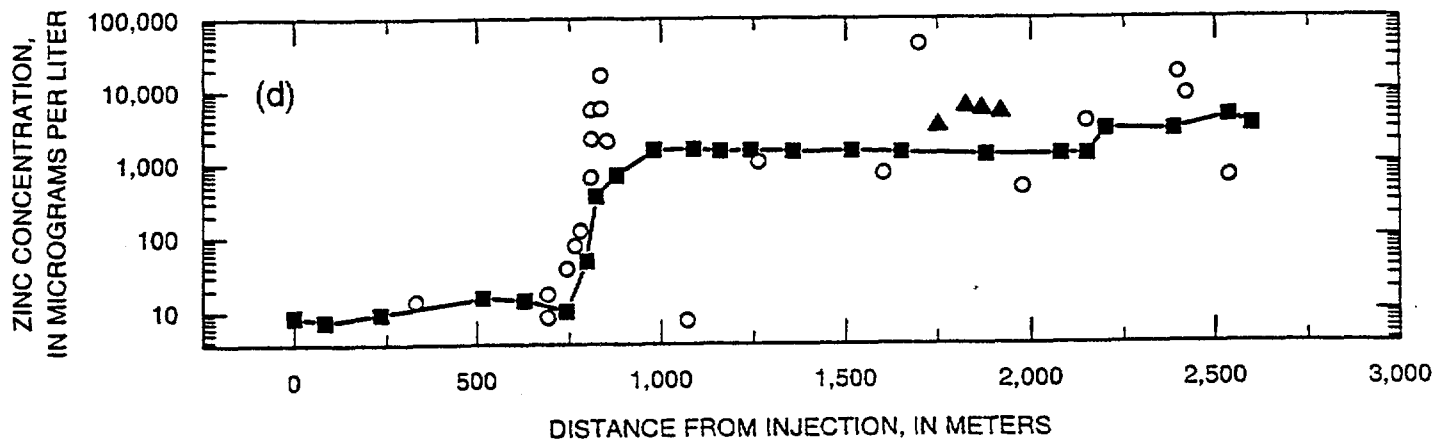
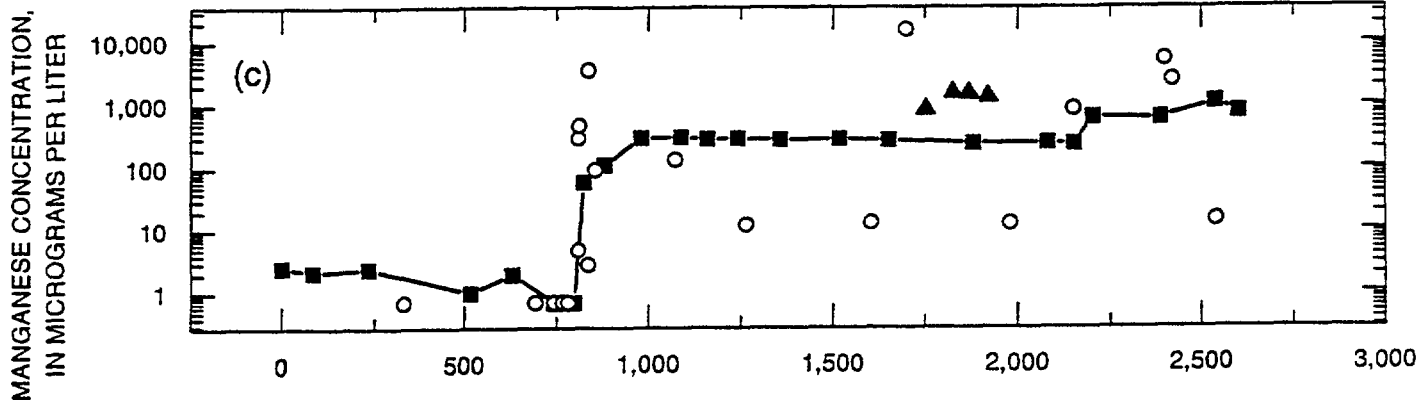
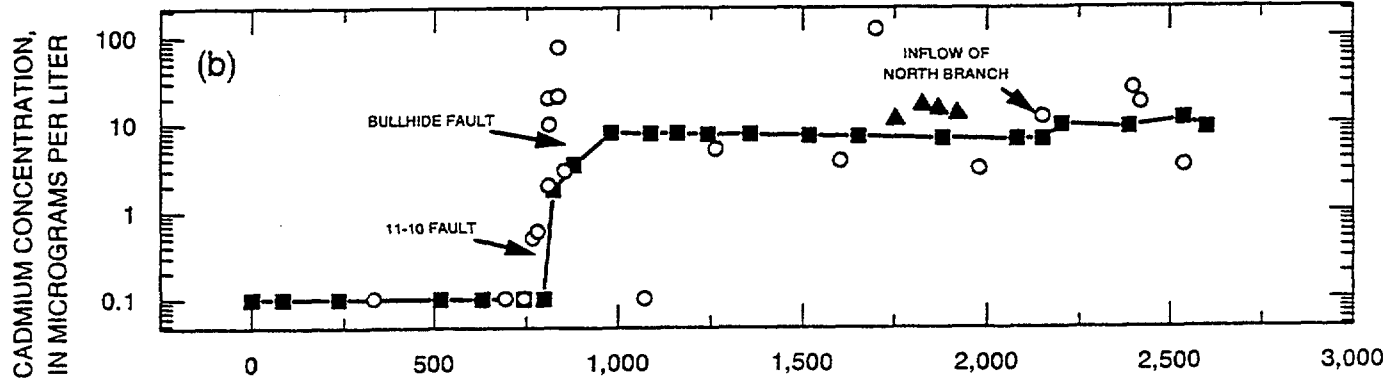
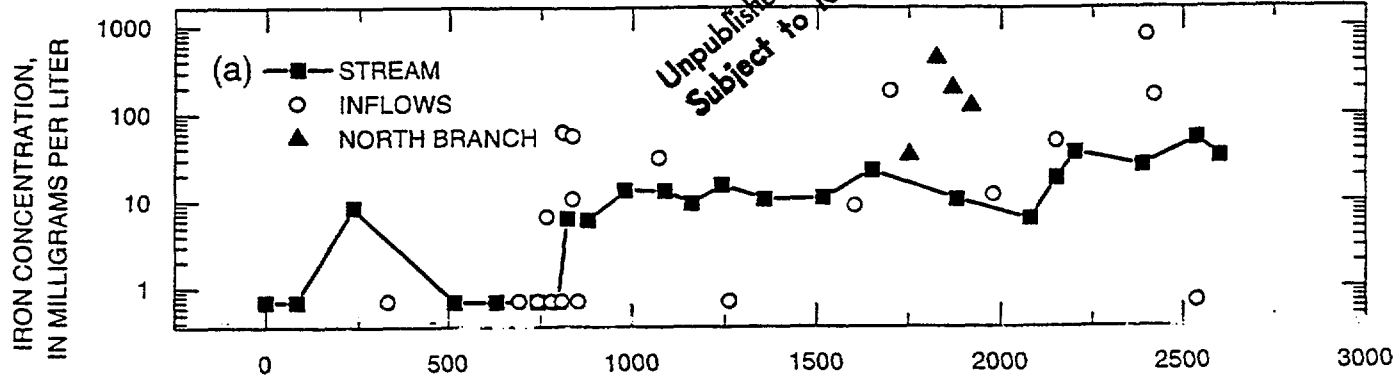
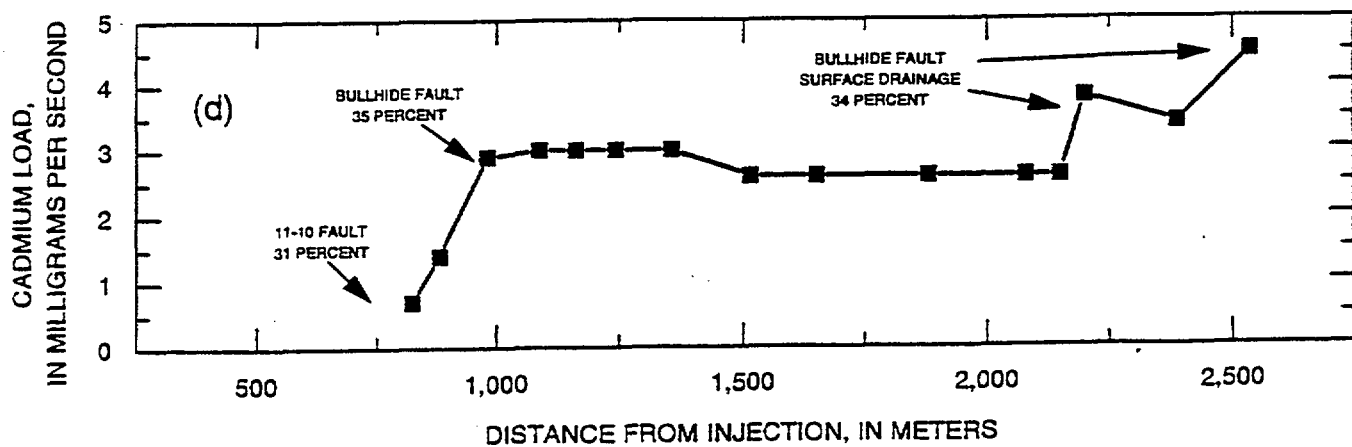
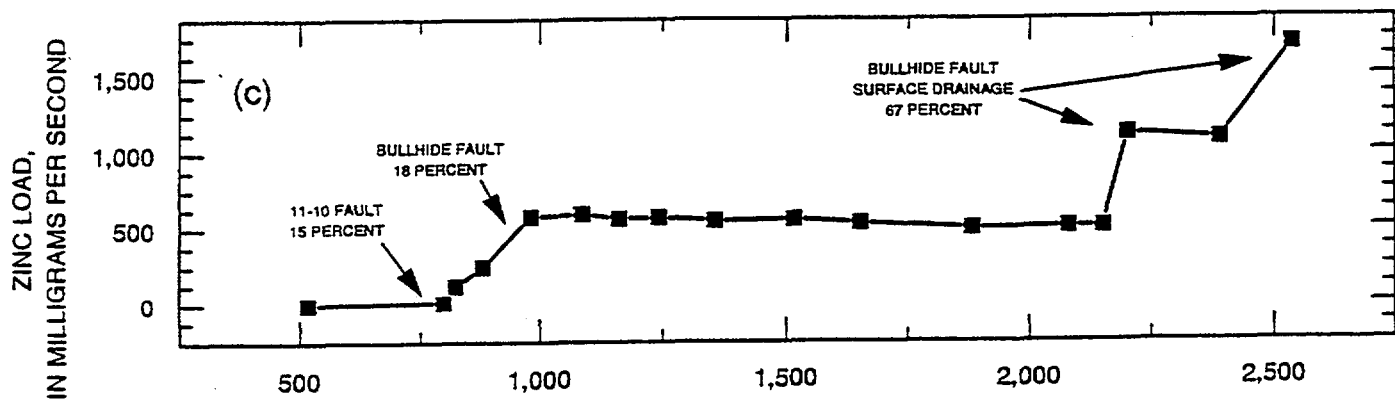
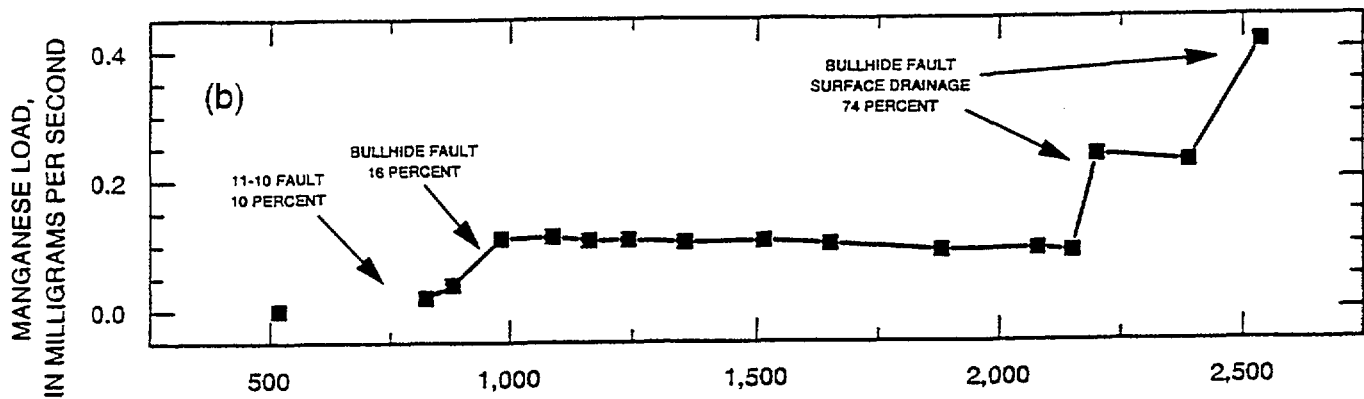
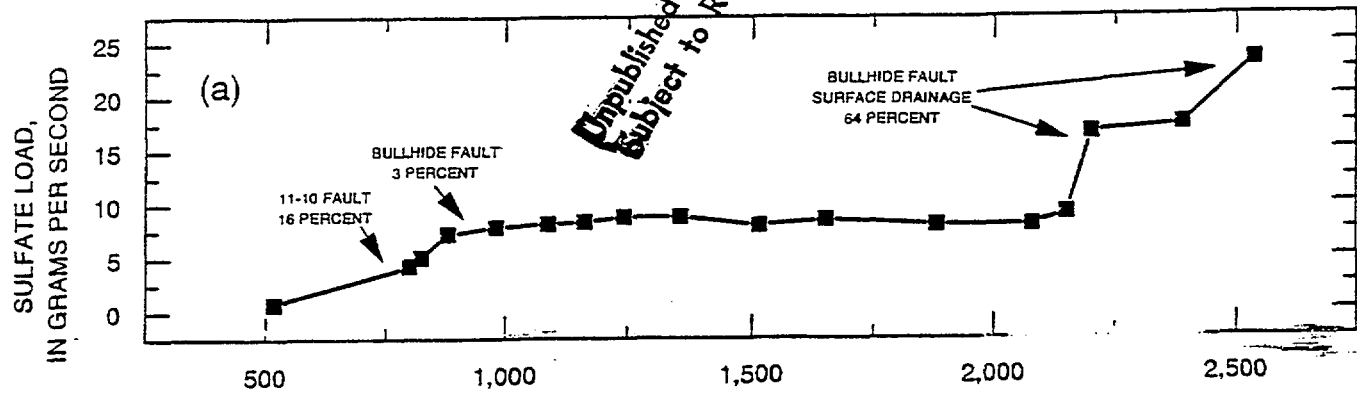


Figure 7--Downstream variation of instream sulfate concentration and inflow concentrations.

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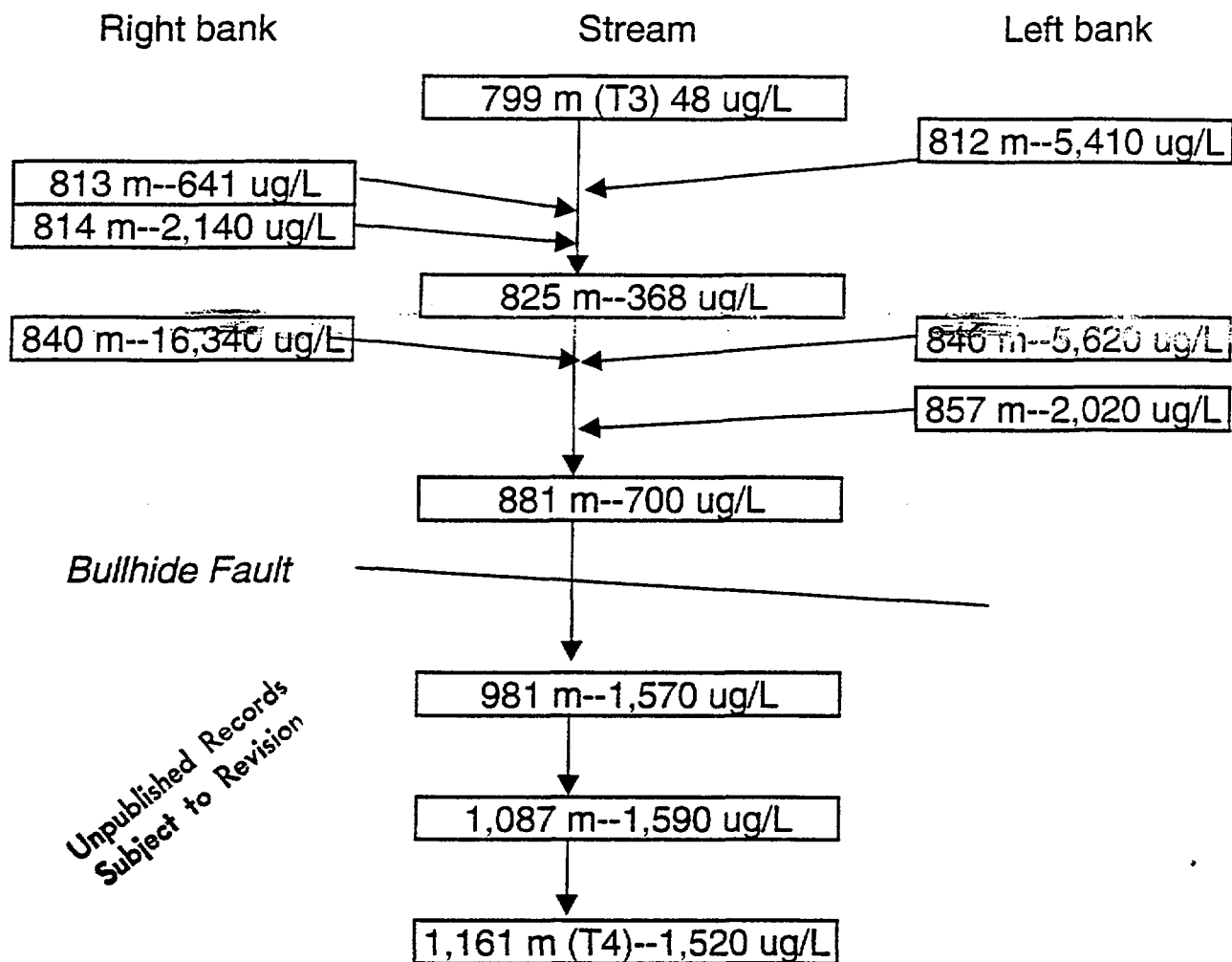
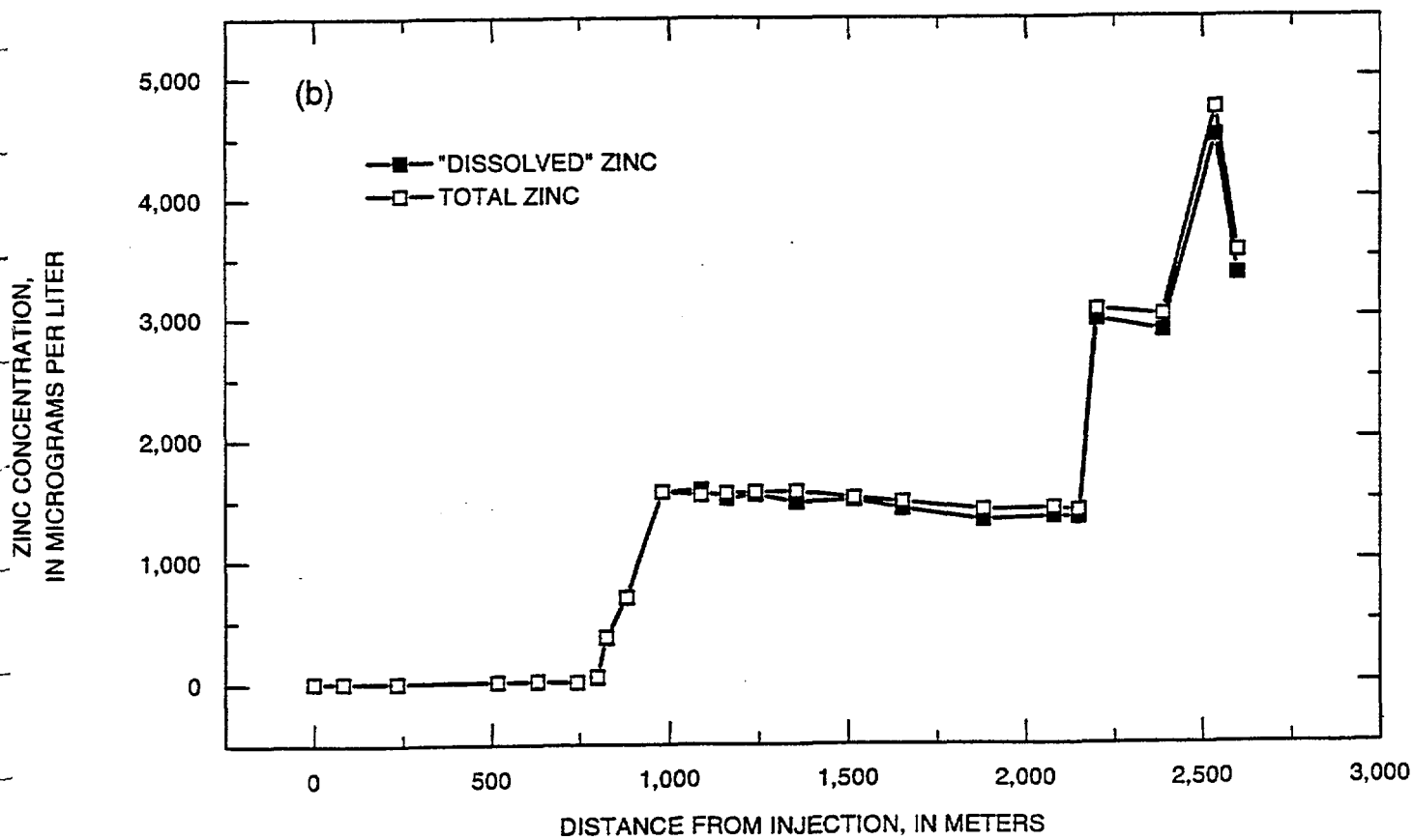
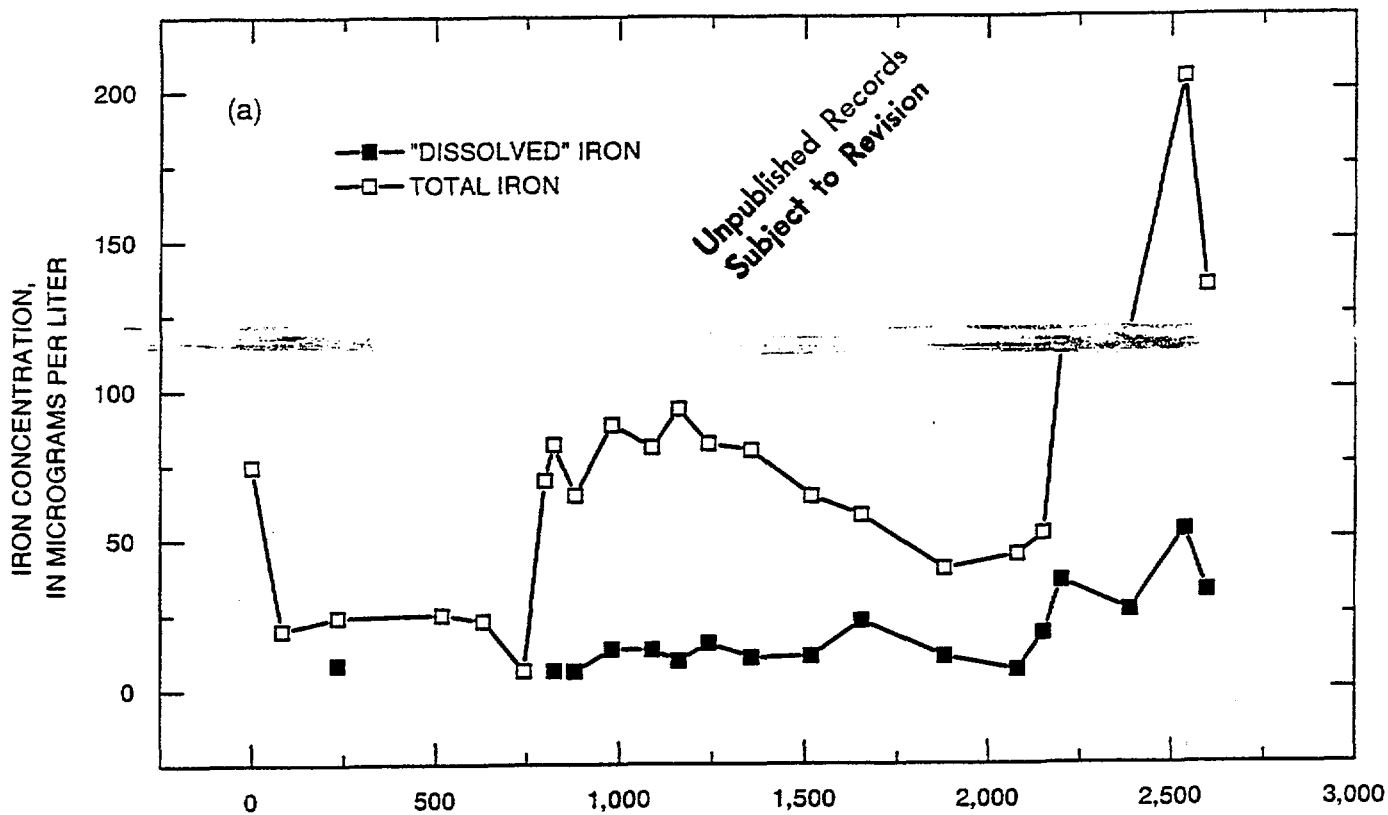


Figure 10--Detail of zinc concentration between sites T3 and T4.



# FRENCH GULCH WATER CHEMISTRY DATA FOR THE SYNOPTIC SAMPLING: July 26, 1996

Sampling Station	Sample Collection Date & Time	Field Measurements			Alk mg/l	TSS mg/l	F mg/l	Cl mg/l	SO <sub>4</sub> mg/l	Br mg/l
		Temp °C	* Cond $\mu$ siemens/cm	pH su						
MW-9	7/26/96 @0909	5.7	546	7.50	102	12	0.22	1.51	190	1.55
FG-42	7/26/96 @0920	8.0	139	7.31	39.9	<4	0.20	2.14	49.6	<0.5
FG-43	7/26/96 @0924	7.5	214	7.38	40.4	<4	0.21	2.25	60.0	<0.5
MW-20	7/26/96 @0922	5.4	611	7.06	115	12	0.34	1.70	187	<0.5
FG-46	7/26/96 @0934	7.0	122	7.28	39.1	<4	0.21	1.84	26.8	<0.5
FG-45	7/26/96 @0947	7.5	170	7.28	42.5	<4	<0.2	2.14	42.3	<0.5
FG-56	7/26/96 @0942	8.0	280	6.97	37.5	<4	0.20	2.25	98.1	<0.5
ORO-1	7/26/96 @0942	8.0	2011	4.34	<5	8	1.00	26.2	1300	<0.5
FG-44	7/26/96 @0952	7.0	412	7.01	29.6	<4	0.20	2.53	181	<0.5
FG-55	7/26/96 @1006	8.0	184	7.32	42.0	<4	<0.2	2.18	42.5	<0.5
MW-3	7/26/96 @1017	8.2	3480	5.76	35.4	168	<0.2	2.83	2510	2.09
FG-54	7/26/96 @1040	7.5	206	7.19	39.9	<4	<0.2	2.13	57.6	<0.5
FG-53	7/26/96 @1041	9.0	132	7.19	45.0	<4	<0.2	2.28	22.9	<0.5
FG-52	7/26/96 @1053	11.0	128	7.26	45.8	<4	<0.2	2.33	22.5	<0.5
MW-1	7/26/96 @1123	8.6	2676	6.13	95.3	16	<0.2	1.98	1910	1.81
MW-16	7/26/96 @1113	8.6	2676	6.34	119	14	<0.2	1.99	1870	1.79
FG-51	7/26/96 @1107	7.5	137	7.34	41.1	<4	<0.2	2.01	25.2	<0.5
FG-50	7/26/96 @1114	8.5	137	7.27	45.1	<4	<0.2	2.32	22.6	<0.5
FG-39	7/26/96 @1125	9.0	192	7.17	43.5	<4	<0.2	2.24	42.4	<0.5
FG-6C	7/26/96 @1155	7.3	3488	6.19	70.0	26	<0.2	3.92	2550	2.15
MSRW-3	7/26/96 @1136	9.2	2801	5.85	13.2	46	1.06	1.95	1970	<0.5

\* Conductivity probe was not calibrated before use. Standards were measured throughout the field event and the conductivity measurements were corrected using a regression analysis.

# FRENCH GULCH WATER CHEMISTRY DATA FOR THE SYNOPTIC SAMPLING: July 26, 1996

Sampling Station	Sample Collection Date & Time	---- Field Measurements ----			Alk mg/l	TSS mg/l	F mg/l	Cl mg/l	SO <sub>4</sub> mg/l	Br mg/l
		Temp °C	* Cond $\mu$ siemens/cm	pH su						
FG-38	7/26/96 @1138	5.0	860	6.63	26.3	<4	0.30	2.37	400	<0.5
FG-37	7/26/96 @1147	10.0	138	7.35	46.2	<4	<0.2	2.30	22.9	<0.5
FG-41	7/26/96 @1147	9.0	244	7.30	41.3	<4	<0.2	2.23	67.7	<0.5
FG-40	7/26/96 @1155	9.0	251	7.38	40.4	<4	<0.2	2.23	72.4	<0.5
FG-39B	7/26/96 @1140	9.0	262	7.33	39.6	<4	<0.2	2.24	77.4	<0.5
FG-35	7/26/96 @1250	7.5	135	7.61	44.8	<4	0.23	2.37	22.5	<0.5
FG-36B	7/26/96 @1240	6.5	144	7.60	43.1	<4	<0.2	1.97	28.3	<0.5
FG-31	7/26/96 @1333	7.0	138	7.53	45.6	<4	<0.2	2.33	22.8	<0.5
FG-31 Rep	7/26/96 @1333	----	----	----	----	----	----	----	----	----
FG-33	7/26/96 @1312	8.0	137	7.70	45.1	<4	<0.2	2.34	22.6	<0.5
FG-32	7/26/96 @1330	6.5	135	7.72	43.4	<4	<0.2	2.30	23.0	<0.5
TS-04	7/26/96 @1347	7.0	135	7.74	45.3	<4	<0.2	2.32	22.5	<0.5
FG-25	7/26/96 @1410	9.0	136	7.74	45.1	<4	<0.2	2.33	22.6	<0.5
FG-28	7/26/96 @1358	7.0	135	7.71	45.7	<4	<0.2	2.29	22.5	<0.5
FG-22	7/26/96 @1437	10.0	444	8.09	124	<4	0.28	1.56	99.7	<0.5
FG-18	7/26/96 @1425	8.0	131	8.06	47.2	<4	<0.2	2.26	20.0	<0.5
FG-27	7/26/96 @1410	17.5	366	7.87	119	<4	0.20	1.46	59.5	<0.5
FG-17B	7/26/96 @1453	7.0	112	7.81	44.8	<4	0.20	2.30	16.2	<0.5
FG-17B Rep	7/26/96 @1453	----	----	----	----	----	----	----	----	----
FG-19	7/26/96 @1441	6.0	306	7.53	56.9	<4	0.21	1.44	87.0	<0.5

\* Conductivity probe was not calibrated before use. Standards were measured throughout the field event and the conductivity measurements were corrected using a regression analysis.

# FRENCH GULCH WATER CHEMISTRY DATA FOR THE SYNOPTIC SAMPLING: July 26, 1996

Sampling Station	Sample Collection Date & Time	Field Measurements		pH su	Alk mg/l	TSS mg/l	F mg/l	Cl mg/l	SO <sub>4</sub> mg/l	Br mg/l
		Temp °C	* Cond $\mu$ siemens/cm							
FG-16B	7/26/96 @1514	8.0	135	7.77	41.6	<4	0.21	3.18	24.1	<0.5
FG-16	7/26/96 @1510	-----	266	7.62	52.3	<4	0.23	1.47	72.5	<0.5
FG-16 Rep	7/26/96 @1510	-----	-----	-----	-----	-----	-----	-----	-----	-----
FG-16C	7/26/96 @1514	8.0	144	7.78	40.3	<4	0.20	3.33	26.6	<0.5
FG-13	7/26/96 @1542	8.0	101	8.04	40.9	<4	<0.2	3.45	13.9	<0.5
FG-9D	7/26/96 @1549	5.5	109	8.17	47.9	<4	0.20	1.52	14.7	<0.5
FG-10	7/26/96 @1540	6.5	102	8.50	44.8	4	0.20	1.76	13.9	<0.5
FG-9B	7/26/96 @1558	6.0	95	8.15	42.9	<4	0.20	1.35	12.9	<0.5
FG-09	7/26/96 @1600	11.5	100	8.08	39.4	<4	<0.2	4.08	11.8	<0.5
FG-09 Rep	7/26/96 @1600	-----	-----	-----	-----	-----	-----	-----	-----	-----
FG-12	7/26/96 @1543	6.5	100	8.05	39.8	<4	<0.2	3.55	12.6	<0.5
FG-12 Rep	7/26/96 @1543	-----	-----	-----	-----	-----	-----	-----	-----	-----
FG-9C	7/26/96 @1557	7.0	117	7.90	48.5	<4	0.20	2.09	16.0	<0.5
FG-7	7/26/96 @1620	11.0	98	7.82	40.2	<4	<0.2	4.26	12.0	<0.5
FG-14	7/26/96 @1534	7.0	108	7.96	45.4	<4	0.26	2.20	14.3	<0.5
FG-05	7/26/96 @1647	11.0	98	8.19	40.4	<4	0.25	4.35	11.7	<0.5
FG-06	7/26/96 @1636	8.5	97	8.05	39.1	<4	0.25	3.96	11.7	<0.5
FG-15	7/26/96 @1445	8.0	292	7.27	36.0	<4	0.27	3.15	93.2	<0.5
FG-00	7/26/96 @1658	10.5	84	8.23	39.4	<4	0.24	1.31	11.7	<0.5
FG-03	7/26/96 @1652	11.0	101	8.16	39.9	<4	0.25	4.32	11.7	<0.5

\* Conductivity probe was not calibrated before use. Standards were measured throughout the field event and the conductivity measurements were corrected using a regression analysis.



# FRENCH GULCH WATER CHEMISTRY DATA FOR THE SYNOPTIC SAMPLING: July 26, 1996

Sampling Station	Sample Collection Date & Time	TOC mg/l	NH <sub>3</sub> mg/l	NO <sub>2</sub> /NO <sub>3</sub> mg/l	PO <sub>4</sub> mg/l	Ca-d mg/l	Mg-d mg/l	Hardness mg/l	Na-d mg/l	K-d mg/l
MW-9	7/26/96 @0909	<1.5	<0.05	<0.05	0.03	106.5	8.36	300	3.04	1.4
FG-42	7/26/96 @0920	<1.5	<0.05	<0.05	<0.02	26.82	4.19	84.2	1.93	<1
FG-43	7/26/96 @0924	<1.5	<0.05	<0.05	<0.02	30.09	5.00	95.7	2.15	<1
MW-20	7/26/96 @0922	<1.5	<0.05	<0.05	0.03	60.86	9.82	192	52.54	1.5
FG-46	7/26/96 @0934	<1.5	<0.05	<0.05	<0.02	21.27	2.63	63.9	1.60	1.2
FG-45	7/26/96 @0947	<1.5	<0.05	<0.05	<0.02	26.52	3.90	82.3	2.05	<1
FG-56	7/26/96 @0942	<1.5	<0.05	<0.05	<0.02	39.29	7.72	130	2.46	1.3
ORO-1	7/26/96 @0942	6.2	0.14	<0.05	<0.02	246.6	84.85	965	9.53	4.5
FG-44	7/26/96 @0952	<1.5	<0.05	<0.05	<0.02	52.80	12.15	182	2.71	<1
FG-55	7/26/96 @1006	<1.5	<0.05	<0.05	<0.02	28.18	4.08	87.2	2.13	<1
MW-3	7/26/96 @1017	<1.5	0.67	0.07	<0.02	414.9	154.6	1670	12.60	1.4
FG-54	7/26/96 @1040	<1.5	<0.05	<0.05	<0.02	29.99	4.68	94.2	2.03	<1
FG-53	7/26/96 @1041	<1.5	<0.05	<0.05	<0.02	22.71	2.60	67.4	2.02	<1
FG-52	7/26/96 @1053	<1.5	<0.05	<0.05	<0.02	23.02	2.60	68.2	2.05	<1
MW-1	7/26/96 @1123	1.9	0.29	0.05	<0.02	387.9	129.8	1500	12.43	3.7
MW-16	7/26/96 @1113	<1.5	0.25	<0.05	<0.02	425.5	130.3	1600	12.80	4.4
FG-51	7/26/96 @1107	<1.5	<0.05	<0.05	<0.02	22.70	2.53	67.1	1.42	<1
FG-50	7/26/96 @1114	1.8	<0.05	<0.05	<0.02	21.84	2.47	64.7	1.91	<1
FG-39	7/26/96 @1125	<1.5	<0.05	<0.05	<0.02	28.04	4.01	86.5	2.01	<1
FG-6C	7/26/96 @1155	1.7	0.50	0.07	<0.02	380.8	148.1	1560	11.76	4.5
MSRW-3	7/26/96 @1136	<1.5	0.29	<0.05	<0.02	357.4	127.8	1420	11.85	1.5

NOTE: "-d" = Dissolved

# FRENCH GULCH WATER CHEMISTRY DATA FOR THE SYNOPTIC SAMPLING: July 26, 1996

Sampling Station	Sample Collection Date & Time	TOC mg/l	NH <sub>3</sub> mg/l	NO <sub>2</sub> /NO <sub>3</sub> mg/l	PO <sub>4</sub> mg/l	Ca-d mg/l	Mg-d mg/l	Hardness mg/l	Na-d mg/l	K-d mg/l
FG-38	7/26/96 @1138	<1.5	<0.05	<0.05	<0.02	107.0	29.55	389	3.73	1.9
FG-37	7/26/96 @1147	<1.5	<0.05	<0.05	<0.02	22.69	2.54	67.1	1.95	<1
FG-41	7/26/96 @1147	<1.5	<0.05	<0.05	<0.02	34.79	5.72	110	2.18	1.0
FG-40	7/26/96 @1155	<1.5	<0.05	<0.05	<0.02	35.48	5.97	113	2.21	<1
FG-39B	7/26/96 @1140	<1.5	<0.05	<0.05	<0.02	36.15	6.26	116	2.23	<1
FG-35	7/26/96 @1250	<1.5	<0.05	<0.05	<0.02	23.22	2.59	68.6	2.01	<1
FG-36B	7/26/96 @1240	<1.5	<0.05	<0.05	<0.02	24.68	2.94	73.7	1.74	<1
FG-31	7/26/96 @1333	<1.5	<0.05	<0.05	<0.02	23.19	2.60	68.6	2.00	<1
FG-31 Rep	7/26/96 @1333	-----	-----	-----	-----	-----	-----	-----	-----	-----
FG-33	7/26/96 @1312	<1.5	<0.05	<0.05	<0.02	22.81	2.55	67.5	1.98	<1
FG-32	7/26/96 @1330	<1.5	<0.05	<0.05	<0.02	23.32	2.57	68.8	1.96	<1
TS-04	7/26/96 @1347	<1.5	<0.05	<0.05	<0.02	22.64	2.54	67.0	1.97	<1
FG-25	7/26/96 @1410	<1.5	<0.05	<0.05	<0.02	23.04	2.62	68.3	2.01	<1
FG-28	7/26/96 @1358	<1.5	<0.05	<0.05	<0.02	23.17	2.62	68.6	2.02	<1
FG-22	7/26/96 @1437	<1.5	<0.05	<0.05	<0.02	72.64	14.23	240	2.05	1.5
FG-18	7/26/96 @1425	<1.5	<0.05	<0.05	<0.02	23.24	2.49	68.3	1.96	1.5
FG-27	7/26/96 @1410	1.9	<0.05	<0.05	<0.02	63.78	6.07	184	3.36	<1
FG-17B	7/26/96 @1453	<1.5	<0.05	<0.05	<0.02	21.10	1.95	60.7	1.96	<1
FG-17B Rep	7/26/96 @1453	-----	-----	-----	-----	-----	-----	-----	-----	-----
FG-19	7/26/96 @1441	<1.5	<0.05	0.06	<0.02	43.23	8.95	145	1.57	<1

NOTE: "-d" = Dissolved

# FRENCH GULCH WATER CHEMISTRY DATA FOR THE SYNOPTIC SAMPLING: July 26, 1996

Sampling Station	Sample Collection Date & Time	TOC mg/l	NH <sub>3</sub> mg/l	NO <sub>2</sub> /NO <sub>3</sub> mg/l	PO <sub>4</sub> mg/l	Ca-d mg/l	Mg-d mg/l	Hardness mg/l	Na-d mg/l	K-d mg/l
FG-16B	7/26/96 @1514	<1.5	<0.05	<0.05	<0.02	23.14	2.39	67.6	2.49	<1
FG-16	7/26/96 @1510	<1.5	<0.05	0.06	<0.02	39.35	7.75	130	1.58	<1
FG-16 Rep	7/26/96 @1510	-----	-----	-----	-----	-----	-----	-----	-----	-----
FG-16C	7/26/96 @1514	<1.5	<0.05	<0.05	<0.02	23.18	2.72	69.1	2.66	<1
FG-13	7/26/96 @1542	<1.5	<0.05	<0.05	<0.02	20.04	1.65	56.8	2.74	<1
FG-9D	7/26/96 @1549	<1.5	<0.05	<0.05	<0.02	22.10	1.93	63.1	1.45	<1
FG-10	7/26/96 @1540	<1.5	<0.05	<0.05	<0.02	19.97	1.74	57.0	1.58	<1
FG-9B	7/26/96 @1558	<1.5	<0.05	<0.05	<0.02	19.39	1.71	55.5	1.28	<1
FG-09	7/26/96 @1600	<1.5	<0.05	<0.05	<0.02	17.70	1.42	50.0	3.57	<1
FG-09 Rep	7/26/96 @1600	-----	-----	-----	-----	-----	-----	-----	-----	-----
FG-12	7/26/96 @1543	<1.5	<0.05	<0.05	<0.02	18.44	1.50	52.2	2.87	<1
FG-12 Rep	7/26/96 @1543	-----	-----	-----	-----	-----	-----	-----	-----	-----
FG-9C	7/26/96 @1557	<1.5	<0.05	<0.05	<0.02	22.81	1.98	65.1	1.83	<1
FG-7	7/26/96 @1620	<1.5	<0.05	<0.05	<0.02	17.48	1.40	49.4	3.62	<1
FG-14	7/26/96 @1534	<1.5	<0.05	<0.05	<0.02	22.03	1.92	62.9	2.01	<1
FG-05	7/26/96 @1647	<1.5	<0.05	<0.05	<0.02	18.62	1.47	52.5	4.20	<1
FG-06	7/26/96 @1636	<1.5	<0.05	<0.05	<0.02	18.34	1.44	51.7	3.35	<1
FG-15	7/26/96 @1445	<1.5	<0.05	<0.05	<0.02	33.14	8.07	116	2.53	<1
FG-00	7/26/96 @1658	<1.5	<0.05	<0.05	<0.02	17.75	1.43	50.2	1.25	<1
FG-03	7/26/96 @1652	<1.5	<0.05	<0.05	<0.02	17.85	1.42	50.4	4.00	<1

NOTE: "-d" = Dissolved

# FRENCH GULCH WATER CHEMISTRY DATA FOR THE SYNOPTIC SAMPLING: July 26, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk mg/l	Hardness mg/l	Cd-t µg/l	Cd-d µg/l	Cr-t µg/l	Cr-d µg/l	Cu-t µg/l	Cu-d µg/l
MW-9	7/26/96 @0909	7.50	102	300	9.2	1.3	<4	<4	7.9	<0.8
FG-42	7/26/96 @0920	7.31	39.9	84.2	10.4	8.9	<4	<4	<0.8	<0.8
FG-43	7/26/96 @0924	7.38	40.4	95.7	12.3	11.5	<4	<4	1.5	1.8
MW-20	7/26/96 @0922	7.06	115	192	0.5	<0.5	5.6	<4	1.0	<0.8
FG-46	7/26/96 @0934	7.28	39.1	63.9	4.1	3.3	<4	<4	<0.8	<0.8
FG-45	7/26/96 @0947	7.28	42.5	82.3	11.4	9.3	<4	<4	<0.8	<0.8
FG-56	7/26/96 @0942	6.97	37.5	130	19.9	17.2	<4	<4	<0.8	<0.8
ORO-1	7/26/96 @0942	4.34	<5	965	370	361	<4	<4	170.8	92.1
FG-44	7/26/96 @0952	7.01	29.6	182	30.9	25.1	<4	<4	<0.8	<0.8
FG-55	7/26/96 @1006	7.32	42.0	87.2	11.5	9.8	<4	<4	<0.8	<0.8
MW-3	7/26/96 @1017	5.76	35.4	1670	164	146	<4	<4	12.8	<0.8
FG-54	7/26/96 @1040	7.19	39.9	94.2	12.7	12.0	<4	<4	0.9	1.0
FG-53	7/26/96 @1041	7.19	45.0	67.4	7.7	6.7	<4	<4	<0.8	<0.8
FG-52	7/26/96 @1053	7.26	45.8	68.2	7.8	6.8	<4	<4	0.8	<0.8
MW-1	7/26/96 @1123	6.13	95.3	1500	154	143	<4	<4	3.7	1.1
MW-16	7/26/96 @1113	6.34	119	1600	118	114	<4	<4	<0.8	<0.8
FG-51	7/26/96 @1107	7.34	41.1	67.1	3.6	3.1	<4	<4	<0.8	<0.8
FG-50	7/26/96 @1114	7.27	45.1	64.7	8.0	6.9	<4	<4	1.5	0.9
FG-39	7/26/96 @1125	7.17	43.5	86.5	12.0	10.9	<4	<4	1.3	1.5
FG-6C	7/26/96 @1155	6.19	70.0	1560	416	387	<4	<4	<0.8	<0.8
MSRW-3	7/26/96 @1136	5.85	13.2	1420	562	536	<4	<4	145.2	109

NOTE: "-t" = Total Recoverable      "-d" = Dissolved

# FRENCH GULCH WATER CHEMISTRY DATA FOR THE SYNOPTIC SAMPLING: July 26, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk mg/l	Hardness mg/l	Cd-t µg/l	Cd-d µg/l	Cr-t µg/l	Cr-d µg/l	Cu-t µg/l	Cu-d µg/l
FG-38	7/26/96 @1138	6.63	26.3	389	130	121	<4	<4	13.7	13.2
FG-37	7/26/96 @1147	7.35	46.2	67.1	8.2	7.2	<4	<4	<0.8	<0.8
FG-41	7/26/96 @1147	7.30	41.3	110	13.8	12.8	<4	<4	<0.8	<0.8
FG-40	7/26/96 @1155	7.38	40.4	113	13.2	14.4	<4	<4	0.8	<0.8
FG-39B	7/26/96 @1140	7.33	39.6	116	16.7	16.2	<4	<4	1.5	<0.8
FG-35	7/26/96 @1250	7.61	44.8	68.6	7.8	7.4	<4	<4	<0.8	<0.8
FG-36B	7/26/96 @1240	7.60	43.1	73.7	4.7	3.7	<4	<4	<0.8	<0.8
FG-31	7/26/96 @1333	7.53	45.6	68.6	8.0	7.6	<4	<4	<0.8	<0.8
FG-31 Rep	7/26/96 @1333	-----	-----	-----	7.9	-----	<4	-----	0.8	-----
FG-33	7/26/96 @1312	7.70	45.1	67.5	8.0	7.8	<4	<4	0.8	<0.8
FG-32	7/26/96 @1330	7.72	43.4	68.8	5.7	5.1	<4	<4	<0.8	<0.8
TS-04	7/26/96 @1347	7.74	45.3	67.0	8.0	7.9	<4	<4	<0.8	<0.8
FG-25	7/26/96 @1410	7.74	45.1	68.3	8.1	8.0	<4	<4	<0.8	<0.8
FG-28	7/26/96 @1358	7.71	45.7	68.6	8.5	7.9	<4	<4	2.1	<0.8
FG-22	7/26/96 @1437	8.09	124	240	3.2	2.9	<4	<4	<0.8	<0.8
FG-18	7/26/96 @1425	8.06	47.2	68.3	3.9	3.5	<4	<4	<0.8	<0.8
FG-27	7/26/96 @1410	7.87	119	184	<0.5	<0.5	<4	<4	<0.8	<0.8
FG-17B	7/26/96 @1453	7.81	44.8	60.7	2.5	1.8	<4	<4	0.9	<0.8
FG-17B Rep	7/26/96 @1453	-----	-----	-----	2.4	-----	<4	-----	1.2	-----
FG-19	7/26/96 @1441	7.53	56.9	145	19.6	20.9	<4	<4	<0.8	<0.8

NOTE: \*-t\* = Total Recoverable      \*-d\* = Dissolved

# FRENCH GULCH WATER CHEMISTRY DATA FOR THE SYNOPTIC SAMPLING: July 26, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk mg/l	Hardness mg/l	Cd-t µg/l	Cd-d µg/l	Cr-t µg/l	Cr-d µg/l	Cu-t µg/l	Cu-d µg/l
FG-16B	7/26/96 @1514	7.77	41.6	67.6	2.4	2.0	<4	<4	<0.8	<0.8
FG-16	7/26/96 @1510	7.62	52.3	130	18.2	19.8	7.3	<4	<0.8	<0.8
FG-16 Rep	7/26/96 @1510	-----	-----	-----	18.7	-----	<4	-----	<0.8	-----
FG-16C	7/26/96 @1514	7.78	40.3	69.1	10.8	9.9	<4	<4	3.2	0.8
FG-13	7/26/96 @1542	8.04	40.9	56.8	1.2	0.6	<4	<4	<0.8	<0.8
FG-9D	7/26/96 @1549	8.17	47.9	63.1	<0.5	<0.5	<4	<4	<0.8	<0.8
FG-10	7/26/96 @1540	8.50	44.8	57.0	0.8	<0.5	<4	<4	<0.8	<0.8
FG-9B	7/26/96 @1558	8.15	42.9	55.5	<0.5	<0.5	<4	<4	<0.8	<0.8
FG-09	7/26/96 @1600	8.08	39.4	50.0	<0.5	<0.5	<4	<4	<0.8	<0.8
FG-09 Rep	7/26/96 @1600	-----	-----	-----	<0.5	-----	<4	-----	<0.8	-----
FG-12	7/26/96 @1543	8.05	39.8	52.2	0.7	0.5	<4	<4	<0.8	0.8
FG-12 Rep	7/26/96 @1543	-----	-----	-----	0.6	-----	<4	-----	<0.8	-----
FG-9C	7/26/96 @1557	7.90	48.5	65.1	<0.5	<0.5	<4	<4	<0.8	<0.8
FG-7	7/26/96 @1620	7.82	40.2	49.4	<0.5	<0.5	<4	<4	<0.8	<0.8
FG-14	7/26/96 @1534	7.96	45.4	62.9	0.8	<0.5	<4	<4	<0.8	<0.8
FG-05	7/26/96 @1647	8.19	40.4	52.5	<0.5	<0.5	<4	<4	<0.8	<0.8
FG-06	7/26/96 @1636	8.05	39.1	51.7	<0.5	<0.5	<4	<4	<0.8	<0.8
FG-15	7/26/96 @1445	7.27	36.0	116	75.6	76.4	<4	<4	7.5	3.8
FG-00	7/26/96 @1658	8.23	39.4	50.2	<0.5	<0.5	<4	<4	<0.8	<0.8
FG-03	7/26/96 @1652	8.16	39.9	50.4	<0.5	<0.5	<4	<4	<0.8	<0.8

NOTE: "-t" = Total Recoverable      "-d" = Dissolved

# FRENCH GULCH WATER CHEMISTRY DATA FOR THE SYNOPTIC SAMPLING: July 26, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk mg/l	Hardness mg/l	Ag-t µg/l	Ag-d µg/l	Zn-t µg/l	Zn-d µg/l	Al-t µg/l	Al-d µg/l
MW-9	7/26/96 @0909	7.50	102	300	<0.2	<0.2	345.3	74.9	2280	50
FG-42	7/26/96 @0920	7.31	39.9	84.2	<0.2	<0.2	3548.2	3357.9	<40	<40
FG-43	7/26/96 @0924	7.38	40.4	95.7	<0.2	<0.2	4741.5	4511.0	<40	43
MW-20	7/26/96 @0922	7.06	115	192	<0.2	<0.2	44.1	18.8	967	<40
FG-46	7/26/96 @0934	7.28	39.1	63.9	<0.2	<0.2	701.8	646.7	<40	44
FG-45	7/26/96 @0947	7.28	42.5	82.3	<0.2	<0.2	3015.9	2882.6	<40	40
FG-56	7/26/96 @0942	6.97	37.5	130	<0.2	<0.2	8658.3	8636.5	<40	<40
ORO-1	7/26/96 @0942	4.34	<5	965	1.00	<0.2	161900	157130	2119	2184
FG-44	7/26/96 @0952	7.01	29.6	182	<0.2	<0.2	18029	17104	<40	<40
FG-55	7/26/96 @1006	7.32	42.0	87.2	<0.2	<0.2	3055.0	2976.1	40	<40
MW-3	7/26/96 @1017	5.76	35.4	1670	0.80	<0.2	230460	212240	7140	154
FG-54	7/26/96 @1040	7.19	39.9	94.2	<0.2	<0.2	3991.0	3744.7	131	<40
FG-53	7/26/96 @1041	7.19	45.0	67.4	<0.2	<0.2	1407.0	1349.2	77	<40
FG-52	7/26/96 @1053	7.26	45.8	68.2	<0.2	<0.2	1431.7	1360.3	43	<40
MW-1	7/26/96 @1123	6.13	95.3	1500	<0.2	<0.2	197120	183720	147	96
MW-16	7/26/96 @1113	6.34	119	1600	<0.2	<0.2	155150	144400	89	47
FG-51	7/26/96 @1107	7.34	41.1	67.1	<0.2	<0.2	486.7	470.4	<40	<40
FG-50	7/26/96 @1114	7.27	45.1	64.7	<0.2	<0.2	1417.4	1335.1	66	<40
FG-39	7/26/96 @1125	7.17	43.5	86.5	<0.2	<0.2	3242.0	3184.7	55	76
FG-6C	7/26/96 @1155	6.19	70.0	1560	<0.2	<0.2	262140	243020	228	142
MSRW-3	7/26/96 @1136	5.85	13.2	1420	<0.2	<0.2	214570	201910	985	515

NOTE: "-t" = Total Recoverable      "-d" = Dissolved

# FRENCH GULCH WATER CHEMISTRY DATA FOR THE SYNOPTIC SAMPLING: July 26, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk mg/l	Hardness mg/l	Ag-t µg/l	Ag-d µg/l	Zn-t µg/l	Zn-d µg/l	Al-t µg/l	Al-d µg/l
FG-38	7/26/96 @1138	6.63	26.3	389	<0.2	<0.2	47248	43917	58	58
FG-37	7/26/96 @1147	7.35	46.2	67.1	<0.2	<0.2	1486.4	1428.6	<40	<40
FG-41	7/26/96 @1147	7.30	41.3	110	<0.2	<0.2	4956.0	4908.7	54	<40
FG-40	7/26/96 @1155	7.38	40.4	113	<0.2	<0.2	5400.0	5395.7	<40	<40
FG-39B	7/26/96 @1140	7.33	39.6	116	<0.2	<0.2	6146.1	5934.9	<40	<40
FG-35	7/26/96 @1250	7.61	44.8	68.6	<0.2	<0.2	1521.4	1502.5	48	<40
FG-36B	7/26/96 @1240	7.60	43.1	73.7	<0.2	<0.2	750.2	737.2	<40	<40
FG-31	7/26/96 @1333	7.53	45.6	68.6	<0.2	<0.2	1565.6	1543.7	68	<40
FG-31 Rep	7/26/96 @1333	-----	-----	-----	<0.2	-----	1573.3	-----	80	-----
FG-33	7/26/96 @1312	7.70	45.1	67.5	<0.2	<0.2	1572.9	1480.4	55	<40
FG-32	7/26/96 @1330	7.72	43.4	68.8	<0.2	<0.2	1098.2	1044.1	210	<40
TS-04	7/26/96 @1347	7.74	45.3	67.0	<0.2	<0.2	1556.8	1515.1	57	<40
FG-25	7/26/96 @1410	7.74	45.1	68.3	<0.2	<0.2	1570.6	1571.9	69	<40
FG-28	7/26/96 @1358	7.71	45.7	68.6	<0.2	<0.2	1546.8	1587.8	81	<40
FG-22	7/26/96 @1437	8.09	124	240	<0.2	<0.2	2002.4	2024.4	<40	<40
FG-18	7/26/96 @1425	8.06	47.2	68.3	<0.2	<0.2	703.7	699.2	72	<40
FG-27	7/26/96 @1410	7.87	119	184	<0.2	<0.2	10.8	7.3	<40	<40
FG-17B	7/26/96 @1453	7.81	44.8	60.7	<0.2	<0.2	372.0	368.2	63	<40
FG-17B Rep	7/26/96 @1453	-----	-----	-----	<0.2	-----	372.8	-----	75	-----
FG-19	7/26/96 @1441	7.53	56.9	145	<0.2	<0.2	5549.0	5616.1	<40	<40

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# FRENCH GULCH WATER CHEMISTRY DATA FOR THE SYNOPTIC SAMPLING: July 26, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk mg/l	Hardness mg/l	Ag-t µg/l	Ag-d µg/l	Zn-t µg/l	Zn-d µg/l	Al-t µg/l	Al-d µg/l
FG-16B	7/26/96 @1514	7.77	41.6	67.6	<0.2	<0.2	637.1	641.2	<40	<40
FG-16	7/26/96 @1510	7.62	52.3	130	<0.2	<0.2	5085.0	5414.5	<40	<40
FG-16 Rep	7/26/96 @1510	-----	-----	-----	<0.2	-----	5103.5	-----	55	-----
FG-16C	7/26/96 @1514	7.78	40.3	69.1	<0.2	<0.2	2001.8	2137.8	<40	<40
FG-13	7/26/96 @1542	8.04	40.9	56.8	<0.2	<0.2	135.4	121.5	127	<40
FG-9D	7/26/96 @1549	8.17	47.9	63.1	<0.2	<0.2	11.2	10.2	<40	<40
FG-10	7/26/96 @1540	8.50	44.8	57.0	<0.2	<0.2	58.5	37.2	119	<40
FG-9B	7/26/96 @1558	8.15	42.9	55.5	<0.2	<0.2	11.2	8.1	<40	<40
FG-09	7/26/96 @1600	8.08	39.4	50.0	<0.2	<0.2	17.4	14.1	<40	<40
FG-09 Rep	7/26/96 @1600	-----	-----	-----	<0.2	-----	20.8	-----	43	-----
FG-12	7/26/96 @1543	8.05	39.8	52.2	<0.2	<0.2	79.8	76.2	<40	<40
FG-12 Rep	7/26/96 @1543	-----	-----	-----	<0.2	-----	81.6	-----	<40	-----
FG-9C	7/26/96 @1557	7.90	48.5	65.1	<0.2	<0.2	17.0	16.9	<40	<40
FG-7	7/26/96 @1620	7.82	40.2	49.4	<0.2	<0.2	14.8	15.5	<40	<40
FG-14	7/26/96 @1534	7.96	45.4	62.9	<0.2	<0.2	50.5	47.8	62	<40
FG-05	7/26/96 @1647	8.19	40.4	52.5	<0.2	<0.2	10.6	9.3	<40	<40
FG-06	7/26/96 @1636	8.05	39.1	51.7	<0.2	<0.2	14.8	13.6	<40	<40
FG-15	7/26/96 @1445	7.27	36.0	116	<0.2	<0.2	15810	16335	278	<40
FG-00	7/26/96 @1658	8.23	39.4	50.2	<0.2	<0.2	10.2	8.5	55	<40
FG-03	7/26/96 @1652	8.16	39.9	50.4	<0.2	<0.2	8.1	7.3	<40	<40

NOTE: "-t" = Total Recoverable      "-d" = Dissolved

# FRENCH GULCH WATER CHEMISTRY DATA FOR THE SYNOPTIC SAMPLING: July 26, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk mg/l	Hardness mg/l	Fe-t µg/l	Fe-d µg/l	Pb-t µg/l	Pb-d µg/l	Mn-t µg/l	Mn-d µg/l
MW-9	7/26/96 @0909	7.50	102	300	3536.6	<5	31.9	<0.8	1457.0	24.8
FG-42	7/26/96 @0920	7.31	39.9	84.2	134.2	32.4	3.1	<0.8	788.4	762.9
FG-43	7/26/96 @0924	7.38	40.4	95.7	204.3	52.8	4.7	<0.8	1121.2	1091.1
MW-20	7/26/96 @0922	7.06	115	192	860.3	<5	3.9	<0.8	75.0	55.5
FG-46	7/26/96 @0934	7.28	39.1	63.9	61.2	<5	2.4	<0.8	18.1	14.3
FG-45	7/26/96 @0947	7.28	42.5	82.3	117.9	26.1	3.3	0.9	616.8	602.9
FG-56	7/26/96 @0942	6.97	37.5	130	419.6	158.6	8.2	0.9	2320.8	2365.2
ORO-1	7/26/96 @0942	4.34	<5	965	74326	73132	785.31	735.20	33032.5	33601.8
FG-44	7/26/96 @0952	7.01	29.6	182	1028.9	789.1	16.7	4.1	5404.8	5008.2
FG-55	7/26/96 @1006	7.32	42.0	87.2	114.1	36.0	3.3	1.4	667.4	631.4
MW-3	7/26/96 @1017	5.76	35.4	1670	388500	355310	592.14	298.63	85608.3	79547.5
FG-54	7/26/96 @1040	7.19	39.9	94.2	154.5	48.4	4.6	2.1	921.6	831.8
FG-53	7/26/96 @1041	7.19	45.0	67.4	51.8	18.6	0.9	<0.8	254.5	236.6
FG-52	7/26/96 @1053	7.26	45.8	68.2	44.7	6.4	1.3	<0.8	270.3	249.4
MW-1	7/26/96 @1123	6.13	95.3	1500	167720	157080	561.39	479.92	50310.3	47036.7
MW-16	7/26/96 @1113	6.34	119	1600	142640	131150	18.8	16.7	44985.2	41138.4
FG-51	7/26/96 @1107	7.34	41.1	67.1	20.7	11.9	<0.8	<0.8	14.0	12.5
FG-50	7/26/96 @1114	7.27	45.1	64.7	40.1	10.8	1.3	<0.8	266.2	242.6
FG-39	7/26/96 @1125	7.17	43.5	86.5	77.9	33.6	0.8	<0.8	850.8	809.4
FG-6C	7/26/96 @1155	6.19	70.0	1560	333230	306960	540.72	449.46	103829	95954.2
MSRW-3	7/26/96 @1136	5.85	13.2	1420	179690	168170	400.83	220.00	52228.2	49432.6

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# FRENCH GULCH WATER CHEMISTRY DATA FOR THE SYNOPTIC SAMPLING: July 26, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk mg/l	Hardness mg/l	Fe-t µg/l	Fe-d µg/l	Pb-t µg/l	Pb-d µg/l	Mn-t µg/l	Mn-d µg/l
FG-38	7/26/96 @1138	6.63	26.3	389	200.9	181.9	21.4	23.5	17077.5	15340.0
FG-37	7/26/96 @1147	7.35	46.2	67.1	58.2	22.9	<0.8	<0.8	291.3	270.6
FG-41	7/26/96 @1147	7.30	41.3	110	373.6	121.8	5.5	0.9	1357.4	1307.0
FG-40	7/26/96 @1155	7.38	40.4	113	427.1	195.9	6.3	<0.8	1515.2	1465.9
FG-39B	7/26/96 @1140	7.33	39.6	116	928.9	428.3	14.4	<0.8	1597.8	1510.9
FG-35	7/26/96 @1250	7.61	44.8	68.6	64.5	11.0	<0.8	<0.8	299.0	285.2
FG-36B	7/26/96 @1240	7.60	43.1	73.7	13.9	8.9	<0.8	<0.8	14.0	13.0
FG-31	7/26/96 @1333	7.53	45.6	68.6	82.2	15.5	1.1	<0.8	307.0	292.1
FG-31 Rep	7/26/96 @1333	-----	-----	-----	133.9	-----	<0.8	-----	311.3	-----
FG-33	7/26/96 @1312	7.70	45.1	67.5	79.9	10.6	<0.8	<0.8	307.7	280.7
FG-32	7/26/96 @1330	7.72	43.4	68.8	183.4	<5	2.0	<0.8	37.1	12.0
TS-04	7/26/96 @1347	7.74	45.3	67.0	93.6	9.4	<0.8	<0.8	313.3	289.2
FG-25	7/26/96 @1410	7.74	45.1	68.3	88.2	13.4	<0.8	<0.8	320.5	302.0
FG-28	7/26/96 @1358	7.71	45.7	68.6	80.7	13.1	<0.8	<0.8	314.4	305.4
FG-22	7/26/96 @1437	8.09	124	240	<4	<5	<0.8	<0.8	97.0	91.9
FG-18	7/26/96 @1425	8.06	47.2	68.3	64.9	6.1	2.1	<0.8	119.3	111.0
FG-27	7/26/96 @1410	7.87	119	184	277.2	30.8	<0.8	<0.8	183.1	133.7
FG-17B	7/26/96 @1453	7.81	44.8	60.7	82.0	6.4	2.3	<0.8	67.1	59.5
FG-17B Rep	7/26/96 @1453	-----	-----	-----	90.0	-----	2.7	-----	67.6	-----
FG-19	7/26/96 @1441	7.53	56.9	145	15.8	10.5	0.9	<0.8	4.2	2.8

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# FRENCH GULCH WATER CHEMISTRY DATA FOR THE SYNOPTIC SAMPLING: July 26, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk mg/l	Hardness mg/l	Fe-t µg/l	Fe-d µg/l	Pb-t µg/l	Pb-d µg/l	Mn-t µg/l	Mn-d µg/l
FG-16B	7/26/96 @1514	7.77	41.6	67.6	114.6	60.7	<0.8	<0.8	310.6	297.1
FG-16	7/26/96 @1510	7.62	52.3	130	38.8	<5	<0.8	<0.8	8.4	4.8
FG-16 Rep	7/26/96 @1510	-----	-----	-----	21.5	-----	<0.8	-----	6.0	-----
FG-16C	7/26/96 @1514	7.78	40.3	69.1	121.9	60.2	<0.8	<0.8	458.2	466.0
FG-13	7/26/96 @1542	8.04	40.9	56.8	182.8	<5	4.7	<0.8	15.4	<1
FG-9D	7/26/96 @1549	8.17	47.9	63.1	6.4	<5	<0.8	<0.8	<1	<1
FG-10	7/26/96 @1540	8.50	44.8	57.0	136.2	<5	3.3	<0.8	6.8	<1
FG-9B	7/26/96 @1558	8.15	42.9	55.5	8.2	<5	<0.8	<0.8	<1	<1
FG-09	7/26/96 @1600	8.08	39.4	50.0	23.0	<5	1.0	<0.8	4.3	2.0
FG-09 Rep	7/26/96 @1600	-----	-----	-----	81.6	-----	1.7	-----	6.4	-----
FG-12	7/26/96 @1543	8.05	39.8	52.2	48.4	6.6	1.4	<0.8	4.1	<1
FG-12 Rep	7/26/96 @1543	-----	-----	-----	50.4	-----	1.1	-----	5.0	-----
FG-9C	7/26/96 @1557	7.90	48.5	65.1	39.8	<5	0.9	<0.8	1.9	<1
FG-7	7/26/96 @1620	7.82	40.2	49.4	24.9	<5	1.1	<0.8	2.4	1.0
FG-14	7/26/96 @1534	7.96	45.4	62.9	69.9	<5	2.0	<0.8	3.8	<1
FG-05	7/26/96 @1647	8.19	40.4	52.5	24.3	8.5	<0.8	<0.8	4.5	2.5
FG-06	7/26/96 @1636	8.05	39.1	51.7	26.8	<5	0.8	<0.8	1.6	<1
FG-15	7/26/96 @1445	7.27	36.0	116	637.0	54.7	3.2	<0.8	3449.4	3481.8
FG-00	7/26/96 @1658	8.23	39.4	50.2	74.9	<5	1.1	<0.8	6.2	2.6
FG-03	7/26/96 @1652	8.16	39.9	50.4	19.9	<5	1.2	<0.8	4.2	2.2

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# FRENCH GULCH WATER CHEMISTRY DATA FOR THE SYNOPTIC SAMPLING: July 26, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk mg/l	Hardness mg/l	Ni-t µg/l	Ni-d µg/l	As-t µg/l	As-d µg/l
MW-9	7/26/96 @0909	7.50	102	300	<10	<10	7.90	<1
FG-42	7/26/96 @0920	7.31	39.9	84.2	<10	<10	<1	<1
FG-43	7/26/96 @0924	7.38	40.4	95.7	<10	<10	<1	<1
MW-20	7/26/96 @0922	7.06	115	192	<10	<10	<1	<1
FG-46	7/26/96 @0934	7.28	39.1	63.9	<10	<10	<1	<1
FG-45	7/26/96 @0947	7.28	42.5	82.3	<10	<10	<1	1.00
FG-56	7/26/96 @0942	6.97	37.5	130	<10	11.8	<1	<1
ORO-1	7/26/96 @0942	4.34	<5	965	109.6	113.4	2.60	4.20
FG-44	7/26/96 @0952	7.01	29.6	182	17.2	11.8	<1	<1
FG-55	7/26/96 @1006	7.32	42.0	87.2	<10	<10	<1	<1
MW-3	7/26/96 @1017	5.76	35.4	1670	197.4	171.3	36.80	24.40
FG-54	7/26/96 @1040	7.19	39.9	94.2	<10	<10	<1	<1
FG-53	7/26/96 @1041	7.19	45.0	67.4	<10	<10	<1	<1
FG-52	7/26/96 @1053	7.26	45.8	68.2	<10	<10	<1	<1
MW-1	7/26/96 @1123	6.13	95.3	1500	147.6	141.8	46.00	32.90
MW-16	7/26/96 @1113	6.34	119	1600	159.4	140.1	24.00	18.30
FG-51	7/26/96 @1107	7.34	41.1	67.1	<10	<10	<1	<1
FG-50	7/26/96 @1114	7.27	45.1	64.7	<10	<10	<1	<1
FG-39	7/26/96 @1125	7.17	43.5	86.5	<10	<10	<1	1.20
FG-6C	7/26/96 @1155	6.19	70.0	1560	316.4	280.0	7.90	7.70
MSRW-3	7/26/96 @1136	5.85	13.2	1420	124.3	108.2	4.70	2.50

NOTE: "-t" = Total Recoverable      "-d" = Dissolved

# FRENCH GULCH WATER CHEMISTRY DATA FOR THE SYNOPTIC SAMPLING: July 26, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk mg/l	Hardness mg/l	Ni-t µg/l	Ni-d µg/l	As-t µg/l	As-d µg/l
FG-38	7/26/96 @1138	6.63	28.3	389	46.0	39.6	<1	<1
FG-37	7/26/96 @1147	7.35	46.2	67.1	<10	<10	<1	1.50
FG-41	7/26/96 @1147	7.30	41.3	110	<10	<10	<1	1.50
FG-40	7/26/96 @1155	7.38	40.4	113	<10	<10	<1	<1
FG-39B	7/26/96 @1140	7.33	39.6	116	<10	<10	<1	<1
FG-35	7/26/96 @1250	7.61	44.8	68.6	<10	<10	<1	<1
FG-36B	7/26/96 @1240	7.60	43.1	73.7	<10	<10	<1	1.20
FG-31	7/26/96 @1333	7.53	45.6	68.6	<10	<10	<1	<1
FG-31 Rep	7/26/96 @1333	-----	-----	-----	<10	-----	<1	-----
FG-33	7/26/96 @1312	7.70	45.1	67.5	<10	<10	<1	<1
FG-32	7/26/96 @1330	7.72	43.4	68.8	<10	<10	<1	<1
TS-04	7/26/96 @1347	7.74	45.3	67.0	<10	<10	<1	1.30
FG-25	7/26/96 @1410	7.74	45.1	68.3	<10	<10	<1	<1
FG-28	7/26/96 @1358	7.71	45.7	68.6	<10	<10	<1	<1
FG-22	7/26/96 @1437	8.09	124	240	<10	<10	<1	<1
FG-18	7/26/96 @1425	8.06	47.2	68.3	<10	<10	<1	<1
FG-27	7/26/96 @1410	7.87	119	184	<10	<10	<1	<1
FG-17B	7/26/96 @1453	7.81	44.8	60.7	<10	<10	<1	<1
FG-17B Rep	7/26/96 @1453	-----	-----	-----	<10	-----	<1	-----
FG-19	7/26/96 @1441	7.53	56.9	145	<10	<10	<1	<1

NOTE: "-t" = Total Recoverable      "-d" = Dissolved

# FRENCH GULCH WATER CHEMISTRY DATA FOR THE SYNOPTIC SAMPLING: July 26, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk mg/l	Hardness mg/l	Ni-t µg/l	Ni-d µg/l	As-t µg/l	As-d µg/l
FG-16B	7/26/96 @1514	7.77	41.6	67.6	<10	<10	<1	<1
FG-16	7/26/96 @1510	7.62	52.3	130	10.6	<10	<1	<1
FG-16 Rep	7/26/96 @1510	-----	-----	-----	<10	-----	<1	-----
FG-16C	7/26/96 @1514	7.78	40.3	69.1	<10	<10	<1	<1
FG-13	7/26/96 @1542	8.04	40.9	56.8	<10	<10	<1	1.20
FG-9D	7/26/96 @1549	8.17	47.9	63.1	<10	<10	<1	1.00
FG-10	7/26/96 @1540	8.50	44.8	57.0	<10	<10	<1	<1
FG-9B	7/26/96 @1558	8.15	42.9	55.5	<10	<10	<1	<1
FG-09	7/26/96 @1600	8.08	39.4	50.0	<10	<10	<1	<1
FG-09 Rep	7/26/96 @1600	-----	-----	-----	<10	-----	<1	-----
FG-12	7/26/96 @1543	8.05	39.8	52.2	<10	<10	<1	<1
FG-12 Rep	7/26/96 @1543	-----	-----	-----	<10	-----	<1	-----
FG-9C	7/26/96 @1557	7.90	48.5	65.1	<10	<10	<1	<1
FG-7	7/26/96 @1620	7.82	40.2	49.4	<10	<10	<1	<1
FG-14	7/26/96 @1534	7.96	45.4	62.9	<10	<10	<1	<1
FG-05	7/26/96 @1647	8.19	40.4	52.5	<10	<10	<1	<1
FG-06	7/26/96 @1636	8.05	39.1	51.7	<10	<10	<1	1.00
FG-15	7/26/96 @1445	7.27	36.0	116	<10	<10	<1	<1
FG-00	7/26/96 @1658	8.23	39.4	50.2	<10	<10	<1	<1
FG-03	7/26/96 @1652	8.16	39.9	50.4	<10	<10	<1	<1

NOTE: "-t" = Total Recoverable      "-d" = Dissolved

# FRENCH GULCH QA/QC DATA FOR THE SYNOPTIC SAMPLING: July 26, 1996

Sampling Station	Sample Collection Date & Time	Description	TOC mg/l	NH <sub>3</sub> mg/l	NO <sub>2</sub> /NO <sub>3</sub> mg/l	PO <sub>4</sub> mg/l	Ca-d mg/l	Mg-d mg/l	Na-d mg/l	K-d mg/l	As-t µg/l	As-d µg/l
QC-1	7/26/96 @1720	Container Blank	----	----	----	----	----	----	----	----	<1	----
QC-2	7/26/96 @1720	Filter Blank	----	----	----	----	0.04	<0.03	<0.03	<1	----	<1
QC-3	7/26/96 @1720	HNO <sub>3</sub> Blank	----	----	----	----	----	----	----	----	<1	----
QC-4	7/26/96 @1720	H <sub>2</sub> SO <sub>4</sub> Blank	<1.5	<0.05	<0.05	<0.02	----	----	----	----	----	----

Sampling Station	Sample Collection Date & Time	Description	Cd-t µg/l	Cd-d µg/l	Cu-t µg/l	Cu-d µg/l	Pb-t µg/l	Pb-d µg/l	Ag-t µg/l	Ag-d µg/l	Al-t µg/l	Al-d µg/l
QC-1	7/26/96 @1720	Container Blank	<0.5	----	<0.8	----	<0.8	----	<0.2	----	<40	----
QC-2	7/26/96 @1720	Filter Blank	----	<0.5	----	<0.8	----	<0.8	----	<0.2	----	<40
QC-3	7/26/96 @1720	HNO <sub>3</sub> Blank	<0.5	----	<0.8	----	<0.8	----	<0.2	----	<40	----
QC-4	7/26/96 @1720	H <sub>2</sub> SO <sub>4</sub> Blank	----	----	----	----	----	----	----	----	----	----

Sampling Station	Sample Collection Date & Time	Description	Cr-t µg/l	Cr-d µg/l	Fe-t µg/l	Fe-d µg/l	Mn-t µg/l	Mn-d µg/l	Ni-t µg/l	Ni-d µg/l	Zn-t µg/l	Zn-d µg/l
QC-1	7/26/96 @1720	Container Blank	<4	----	<5	----	<1	----	<10	----	<4	----
QC-2	7/26/96 @1720	Filter Blank	----	<4	----	<5	----	1.0	----	<10	----	5.0
QC-3	7/26/96 @1720	HNO <sub>3</sub> Blank	<4	----	<5	----	<1	----	<10	----	<4	----
QC-4	7/26/96 @1720	H <sub>2</sub> SO <sub>4</sub> Blank	----	----	----	----	----	----	----	----	----	----

NOTE: "-t" = Total Recoverable      "-d" = Dissolved



**By Briant A. Kimball, Robert L. Runkel, and Linda J. Gerner**

Water-Resources Investigations Report 98-4078

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## CONVERSION FACTORS AND ABBREVIATED WATER-QUALITY UNITS

Multiply	By	To obtain
kilogram (kg)	2.2046	pound
liter (L)	0.26417	gallon
meter (m)	3.2808	foot
micrometer (μm)	0.0000032808	foot

Water temperature is reported in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by the following equation:

$$^{\circ}\text{F} = 1.8(^{\circ}\text{C}) + 32.$$

Chemical concentration and water temperature are reported only in metric units. Chemical concentration is reported in milligrams per liter (mg/L) or micrograms per liter (μg/L). Milligrams per liter is a unit expressing the mass of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to 1 milligram per liter. For concentrations less than 7,000 milligrams per liter, the numerical value is about the same as for concentrations in parts per million. Specific conductance is reported in microsiemens per centimeter at 25 degrees Celsius (μS/cm).

# Quantification of metal loading in French Gulch, Summit County, Colorado, using a tracer-injection study, July 1996

By Briant A. Kimball, Robert L. Runkel, and Linda J. Gerner

## Abstract

Acid mine drainage degrades the water quality and affects the health of aquatic organisms, including fish, in French Gulch, Colorado, a stream that drains to the Blue and Colorado Rivers. Metals in the water originate from drainage of abandoned and inactive mines in the watershed. Mine drainage enters the stream in a complex pattern. Three tracer injections were used to define hydrologic flowpaths from the mines to the stream and to define hydrologic properties of French Gulch. A lithium chloride tracer, added to the Oro Mine Shaft of the Wellington-Oro Mine, was diluted by the mine pool but did not move from the shaft. This showed that there was no hydrologic connection of the upper mine-shaft water with the downgradient alluvium or with the stream. A sodium bromide tracer, added to water in an alluvial well located next to the stream, did not cause any detectable bromide concentration in a downgradient alluvial well or in the stream. A sodium chloride tracer, added to the stream during a period of 4 days, helped indicate those subreaches of French Gulch where the majority of metal loading occurs. There is substantial inflow of metals where the 11-10 and Bullhide Faults cross the stream, and where surface drainage, originating from the Bullhide Fault, enters the stream. The loading analysis indicates that the metals affecting aquatic life in the stream originate from ground and surface water that drain from the mine pool, except during storm runoff when additional sources may contribute metals.

## Introduction

Acid mine drainage degrades the water quality and affects the health of fish and other aquatic organisms in French Gulch, Colorado, a stream that drains to the Blue and Colorado Rivers (fig. 1). Metals are present in water that drains abandoned and inactive mines in the watershed. This mine drainage enters French Gulch in a complex pattern. Because French Gulch historically was dredged for placer gold mining, the hyporheic zone, the area of alluvium that exchanges water with the stream, is unnatural. This complex hydrology has obscured a consistent picture or conceptual model of the metal loading to the stream from surface- and ground-water inflows. Effective remediation at this site requires an understanding of the diverse physical and biogeochemical processes that control spatial profiles of metal concentrations and other acid constituents. Much of this understanding can come from a detailed mass-loading profile of metals in the stream. A tracer-injection study was designed in cooperation with the Colorado Division of Minerals and Geology to help with plans for remediation by providing a mass-loading curve and to evaluate the effects of instream geochemical processes.

Spatial variations of pH and toxic metals in streams affected by acid mine drainage are the result of the interplay of hydrologic and geochemical processes (Bencala and McKnight, 1987; Kimball and others, 1994; Broshears and others, 1995). The approach used in this study consisted of a tracer-injection study and synoptic sampling to provide the basis for mass-balance calculations that help to interpret these spatial variations. Tracer-injection methods, combined with computer simulations, have reproduced mass-loading curves with steady-state patterns of observed pH and metal concentrations in other streams around the Western United States (Broshears and others, 1993; Kimball and others, 1994; Broshears and others, 1996).

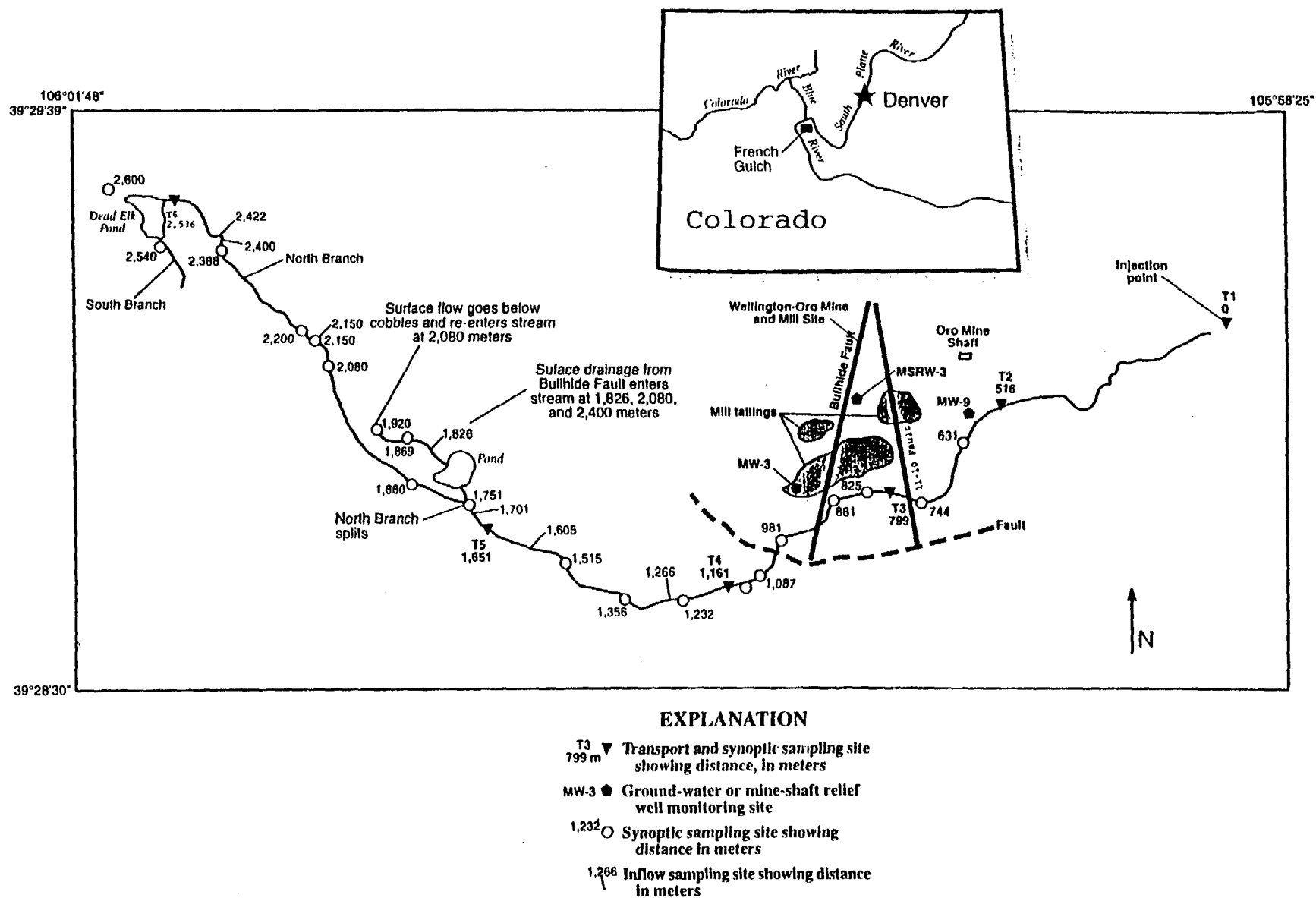


Figure 1. Location of selected surface- and ground-water sampling sites and important geologic features along French Gulch, Colorado.



## Purpose and Scope

The objective of this report is to present a description of the complex hydrology of the French Gulch site using the tracer-injection study and the synoptic sampling. In particular, the tracer injection allows for evaluation of the effect of the hydrology on the fate and transport of the metals in French Gulch.

## Description of Study Area and Conditions at the Time of the Study

French Gulch is an alpine stream that originates above 3,000 m at the continental divide. The main source of streamwater is snowmelt runoff, and the highest flows are during May and June when most runoff occurs. During snowmelt runoff, flow occurs in the North and South Branches of French Gulch downstream from the mine (fig. 1). As flow decreases during the summer, much of the flow goes below the surface in some parts of the stream. Because of the large amount of subsurface flow through the dredged cobbles in French Gulch, water continuously exchanges between the stream and the subsurface.

Results of the tracer injection are particular to the hydrologic conditions at the time of the injection. At the time of this study, surface flow decreased between sites T1 and T2, and then almost vanished between sites T2 and T3. In the vicinity of the 11-10 Fault, however, the flow greatly increased because of the discharge of many springs. Flow continued to increase between sites T3 and T4. Downstream from site T4, the flow was complex. There were visible inflows, but also visible outflows where streamwater flowed away from the stream under cobbles. The stream split about 1,730 m downstream from the injection point, sending about half the flow to a pond north of the stream and half down a channel to the west. Water flowed out of the pond and was visible on the surface to about 1,920 m, where it went below the cobbles. Surface drainage that likely originated at a spring along the Bullhide Fault entered from the right side of the channel at 1,826 m, downstream from the pond. The other channel from the split (at about 1,730 m) was the North Branch of French Gulch, and visibly flowed all the way to Dead Elk Pond. The North Branch received inflow at 2,150 m that likely consisted of the return flow from the pond. Two inflows at 2,400 and 2,422 m were from mine drainage on the north side of the stream. This water likely originated from drainage of the Bullhide Fault but may have had additional contributions from tailings

piles. Flow in the South Branch of French Gulch originated about 200 m upstream from Dead Elk Pond and was not visibly connected to the flow in the North Branch.

## Methods

Three separate tracer injections were used to study the complex hydrology of French Gulch. First, a slug injection of lithium chloride (LiCl) into the Oro Shaft defined the paths of mine water to the alluvium and the stream. Second, a slug injection of sodium bromide (NaBr) into an alluvial well (MW-9) quantified the interaction of the stream with the alluvium. Third, a continuous injection of sodium chloride (NaCl) into the stream quantified hydrologic parameters, including discharge at each sampling site along the stream, residence time of solutes between sites, and transient storage (Stream Solute Workshop, 1990; Bencala and others, 1990a, 1990b). The sequence of injections is listed in table 1.

## Tracer Sampling

Samples were collected to measure the concentrations of injected tracers and to quantify the residence time or "time of travel" in water from wells and in the stream. Residence-time sampling was done in two parts. The first part included sampling of water from selected wells in the bedrock and alluvium to quantify the arrival of LiCl or NaBr from slug injections. This sampling continued for 4 days, mostly at hourly intervals, in six wells. Residence-time samples for the wells were unfiltered because of the difficulty of filtering iron-rich waters in the field. The samples were filtered in the laboratory prior to analysis by atomic adsorption spectrophotometry (AA) and ion chromatography (IC).

The second part included sampling at selected "transport" sites along the stream to quantify the arrival and departure of NaCl. These samples established the hydrologic framework by providing residence time between sites, discharge at each site, stream cross-sectional area, and other parameters needed for transport modeling. This sampling continued for 2 days prior to the synoptic sampling and 1 day after the synoptic sampling to allow time for the alluvial tracer to reach the stream and to help define the hyporheic zone. These samples were filtered on site through 0.45-micrometer ( $\mu\text{m}$ ) membrane filters.

**Table 1.** Sequence of tracer-injection activities and sampling in French Gulch, Colorado

Date	Time	Activity
7/23/96	09:00	Began tracer sampling for wells
	09:15	Slug injection of lithium chloride into Oro Shaft
	09:38	Slug injection of sodium bromide into well MW-9
	10:00	Flow-meter discharge measurements at selected stream sites
7/24/96	09:00	Started sodium chloride injection in the stream (runs into day 5)
	09:00	Began tracer sampling at six sites
	14:42	Added sodium chloride to injection pool
	17:24	Added sodium chloride to injection pool
7/25/96	11:12	Started spot-tracer injections at six sites
	17:20	Added sodium chloride to injection pool
7/26/96	08:00	Synoptic sampling of stream sites and inflows
	11:21	Added sodium chloride to injection pool
7/27/96	09:00	Shut off tracer
	08:30	Time-of-travel sampling
7/28/96	12:00	End of sampling

### Synoptic Sampling

During the NaCl injection, water samples from stream and selected inflows were collected to develop mass-loading profiles for metals and anions. Both filtered and unfiltered samples were collected. Filtered samples were passed through a 0.45- $\mu\text{m}$  filter to determine "operationally defined" dissolved metals; including cadmium (Cd), iron (Fe), manganese (Mn), and zinc (Zn). The use of 0.45- $\mu\text{m}$  filtration was to satisfy regulatory objectives. Filtration of water using 10-kilo-Dalton, 0.1- $\mu\text{m}$ , and 0.45- $\mu\text{m}$  membrane filters indicated a significant difference in Fe concentrations among filtrates (B.A. Kimball, unpub. data, 1996). The concentrations of total-recoverable metals were determined from unfiltered samples.

### Analytical Methods

Anions were analyzed in the 0.45- $\mu\text{m}$  filtered, unacidified samples by ion chromatography. These filtered, unacidified samples also were analyzed for sodium (Na) and lithium (Li) by atomic adsorption. Dissolved and total-recoverable metal concentrations were determined by inductively coupled plasma-atomic emission spectrometry (ICP-AES). Filtered samples

were analyzed for ferrous iron (FeII) colorimetrically. Alkalinity, total suspended solids, and total organic carbon were determined from unfiltered samples.

To present the time series of data from the stream and wells, a smoothed line is plotted on the figures. The smoothed line uses medians to summarize consecutive, overlapping segments of the sequence, for example, the first five data values, then the second through sixth values, and so on (Velleman and Hoaglin, 1981).

## QUANTIFICATION OF METAL LOADING

Results of chemical determinations for tracer concentrations in water from wells and stream sites are listed in appendices 1 and 2. Site descriptions and physical properties of water from the synoptic sampling sites are listed in appendix 3. Results of chemical concentrations in water from the synoptic sampling sites are presented in appendix 4 for major ions and in appendix 5 for filtered and total metals. Data are sorted in downstream order within groups of mainstem and inflow sites to emphasize the downstream changes.

## Tracer Injections in the Wells

### Slug Injection of LiCl in the Oro Mine Shaft

Three kg of LiCl were mixed into 5 L of deionized water and added to the Oro Mine Shaft through 20 m of plastic tubing. After an initial peak and subsequent decline, the concentration of Li remained above the preinjection level for several weeks (fig. 2a). Water from a mine-shaft relief well, MSRW-3, was sampled to detect Li and Cl from the slug injection. No Li was detected in water from well MSRW-3, nor was there a variation in Cl concentration in water from the mine well, MSRW-3 (fig. 2b); or in the alluvial well, MW-3 (fig. 2c).

The initial decrease of Li in the Oro Mine Shaft can best be interpreted as the dilution of Li as it mixed into the mine pool. After mixing, however, there was not a continual decrease of Li, as might be expected if water from the mine pool was moving to the bedrock and the downgradient alluvium. Lithium was not detected in water from MSRW-3 or in any of the stream samples. Thus, the most likely explanation of the trend in Cl concentration is that the mine pool, at least the top of the mine pool in this shaft, was isolated from the ground-water system that supplies metal-rich water to the bedrock and the alluvium. This information is important to help refine the conceptual model of the hydrologic system of the mine, even without an indication of a pathway from the mine pool to the stream. The information indicates that the mine drainage affecting the stream is from lower levels of the mine.

### Slug Injection of NaBr in Well MW-9

One kg of NaBr was mixed into 3 L of deionized water and poured inside the casing of well MW-9 at 09:38 on July 23. The concentration of Br in the well water increased with the slug injection, and then decreased to preinjection levels within 24 hours (fig. 3). Despite the high concentration of Br in water from well MW-9, Br could not be detected in water from the downgradient alluvial well, MW-3, or in water from the stream at any of the sampling sites.

There are three possible reasons why Br was not detected in water from the downgradient alluvial well or in the stream: (1) the downgradient alluvial well may not have been located along a potential flowpath for the Br traveling in the alluvial aquifer, (2) the Br could have been diluted below detection limits by dispersion before it arrived at either the well or the stream, or (3), for both the well and the stream, the travel time of Br to

the downgradient wells could have been greater than the time allotted for sampling. Additional samples collected during the following months did not indicate Br in water from either the well or the stream. The most likely explanation is that water from well MW-9 did not flow to well MW-3.

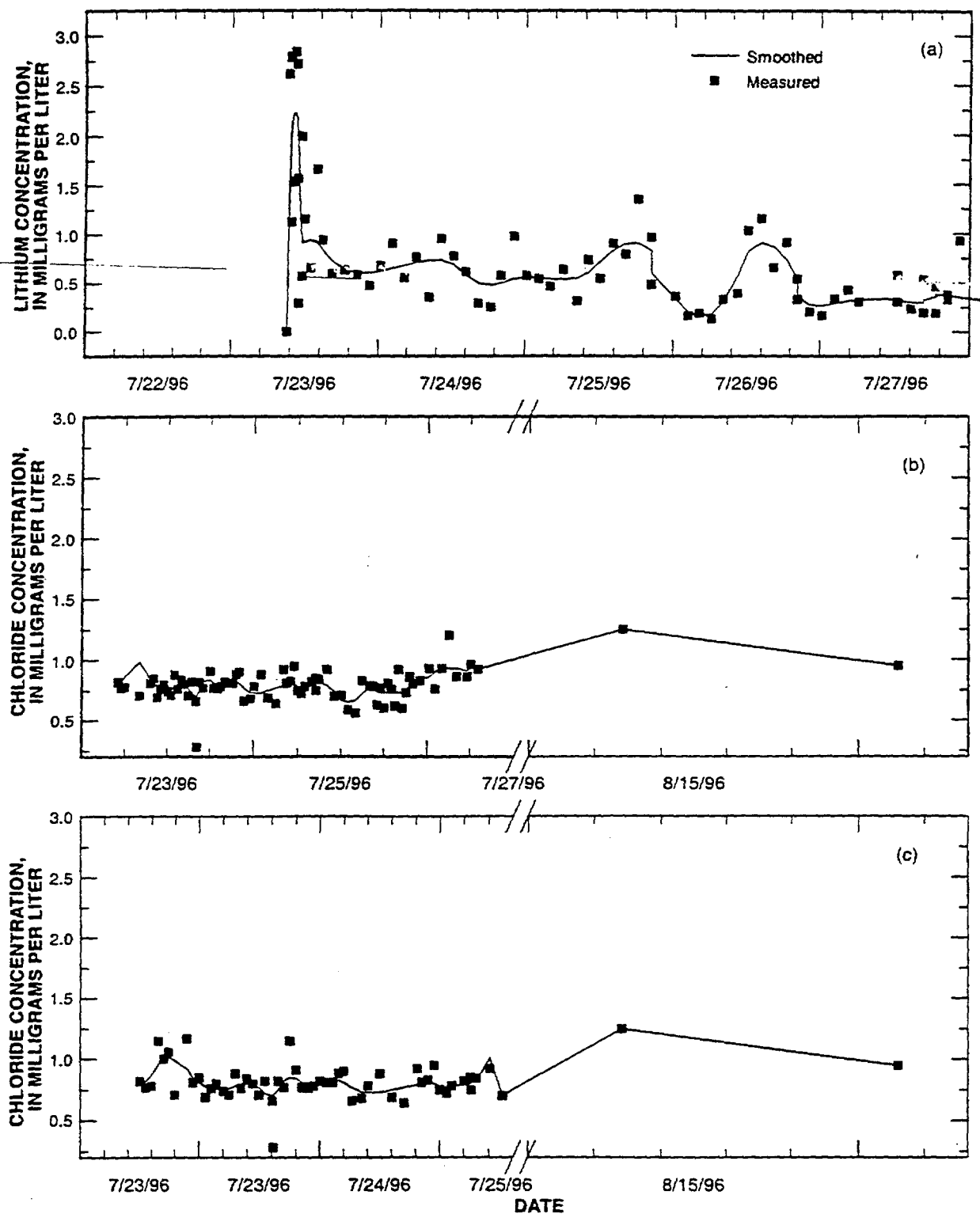
### Tracer Injection in the Stream

The tracer injection for the stream was prepared by adding 400 kg of NaCl to 440 L of streamwater in a 3-m diameter wading pool. This tracer was to be pumped into the stream at a rate that would maintain a constant Cl concentration of a few mg/L. After mixing the solution, however, the pool leaked. Because of this leak, some of the NaCl solution reached the stream before the intended injection began and resulted in Cl concentrations slightly greater than normal background values (fig. 4). Additional NaCl had to be added to the pool periodically during the 4-day injection to compensate for the loss and to avoid a premature end of the injection. These unplanned additions resulted in greater variability in the Cl profile of the stream than otherwise would have been observed (fig. 4). Chloride concentrations at stream sites are listed in appendix 2.

The tracer injection was divided into three periods (fig. 4). The first period was the arrival of the tracer. The second period was a plateau where the Cl concentration should have been at a constant plateau value, which depended on the discharge, at any point downstream. This allows accurate calculation of discharge at any given site along the stream for the synoptic samples. Because of the periodic additions of salt to the pool, there was substantial variation in tracer concentration during the plateau period in French Gulch. By sampling the salt solution being pumped to the stream and monitoring the pump rate, the mass balance of salt and the discharge in the stream could still be determined. The third period includes the departure of the tracer at the downstream sites after the injection was stopped.

### Time of Travel

Information from the arrival and departure periods can be used to calculate the travel time between sites (fig. 4). Despite the complications caused by the leaky pool, the arrival times of the tracer at the downstream sites were not affected. The injection began at 09:00 hours on July 24 and continued until 09:00 on July 27. The time of arrival at a site is defined as the time at which the instream-tracer concentration reaches



**Figure 2.** Concentration of (a) lithium in water from the Oro Mine Shaft, (b) chloride in water from the mine-shaft relief well, MSR-W-3, and (c) chloride in water from the alluvial well, MW-3, near French Gulch, Colorado.

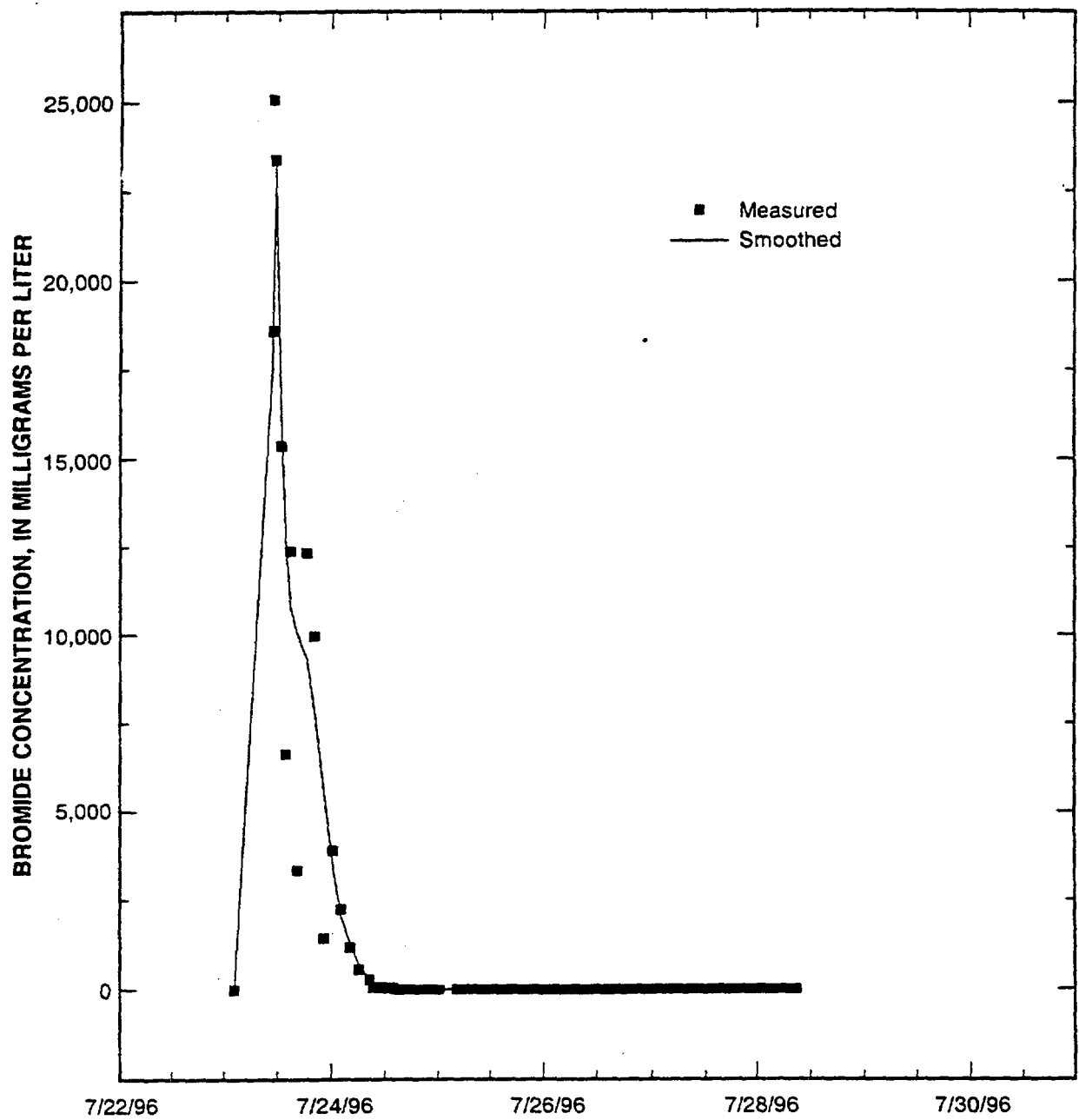


Figure 3. Bromide concentration in water from well MW-9, site of the NaBr slug injection, French Gulch, Colorado.

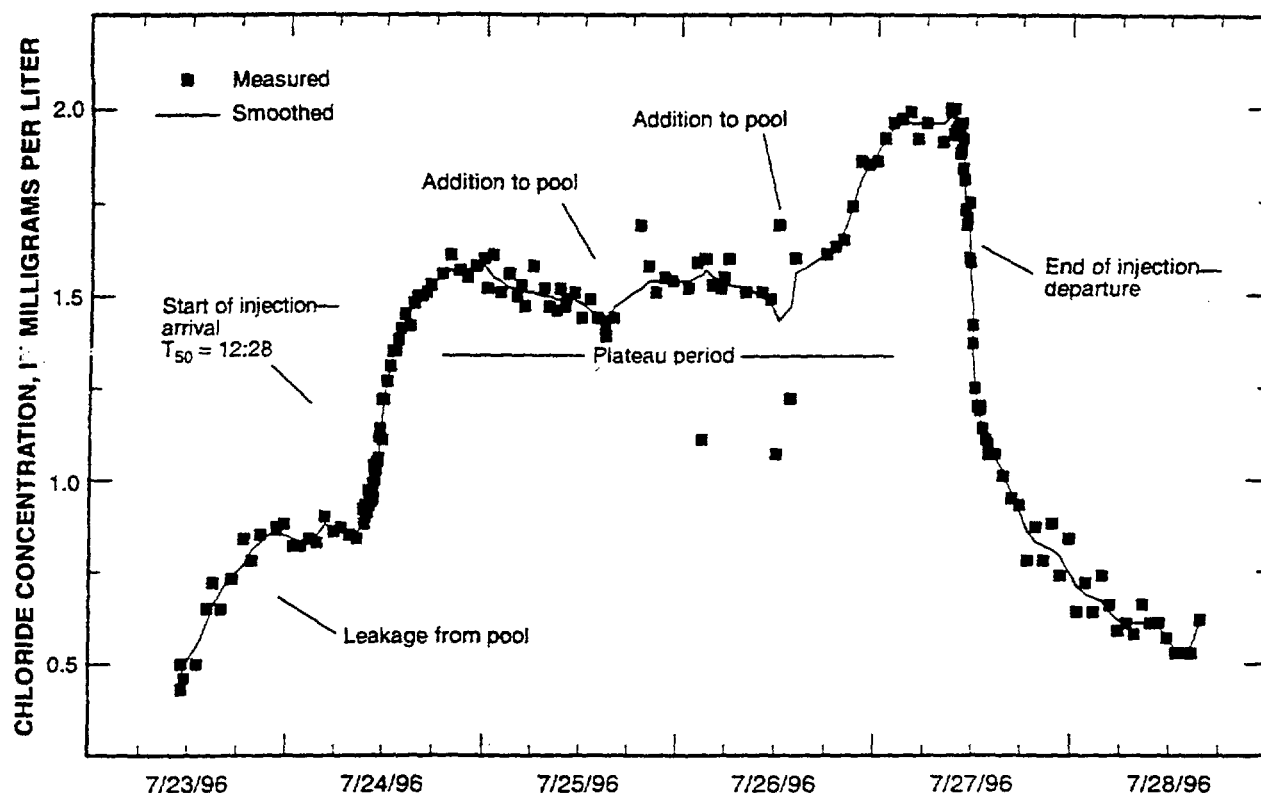


Figure 4. Chloride concentration for site T4 during the period of injection, French Gulch, Colorado.

half of the plateau concentration (Zellweger and others, 1988). Plateau concentrations,  $\frac{1}{2}$  plateau concentrations ( $C_{50}$ ), arrival times ( $T_{50}$ ), travel time between sites, and cumulative travel time downstream are listed in table 2.

The chronology of the tracer concentration at each site can be normalized to allow comparisons of the hydrologic properties between sites (fig. 5). Normalization of transport time was relative to the arrival times in table 2. Normalization of concentration was relative to maximum and background tracer concentrations at each site (see Bencala and others, 1990b). Comparison of the sites indicates a significant difference in arrival of tracer at sites T2 and T4. This difference was caused by the leaky pool and indicates that the Cl entering the stream from the leaking pool entered the hyporheic zone and generally bypassed site T2. Streamflow almost disappeared between sites T2 and T3 and then rejoined the stream just upstream from site T3. Several inflows had Cl concentrations substantially higher than instream concentrations, all on the right bank between sites T2 and T4. The higher concentrations likely were caused by the return of streamwater that had entered the hyporheic zone upstream from site T2.

Effects of solute storage in the hyporheic zone were much more pronounced at the end of the injection period than at the beginning. After 3 days of tracer injection, the bleeding of solutes from transient storage was more pronounced at each downstream site. The effect of the hyporheic zone varied from almost no effect at site T2, which had a rapid return to baseline concentrations, to a pronounced effect at site T6, which had about 40 percent of the maximum tracer concentration still present 24 hours after stopping the injection. In a stream where mining operations have dredged almost the entire reach, the streamflow is complex, and these tracer patterns indicate a clear effect on solute storage.

#### Discharge Profile of the Stream

An evaluation of mass loading along French Gulch requires an accurate discharge measurement at each sampling site. Two characteristics of the streamflow in French Gulch made the calculation of discharge difficult. First, tracer-dilution methods can quantify gains, but not losses of discharge. Once a tracer has mixed into the stream water, the loss of water does not change the concentration of tracer in the remaining

**Table 2.** Instream chloride concentration and travel time at sites downstream from the tracer injection, July 24-27, 1996, French Gulch, Colorado

[m, meters; mg/L, milligrams per liter;  $C_{50}$ , half plateau concentration;  $T_{50}$ , arrival time for the  $C_{50}$  concentration;

<, less than]

Site—Distance downstream	Preinjection concentration (mg/L)	Plateau concentration (mg/L)	$C_{50}$ (mg/L)	$T_{50}$ (hours)	Time between sites (minutes)	Cumulative time (minutes)
T1— 0 m	0.09	1.30	0.7	09:01	< 2	< 2
T2— 516 m	.08	1.67	.87	09:23	23	23
T3— 799 m	.76	1.21	.99	10:59	96	119
T4—1,161 m	.84	1.48	1.16	11:38	39	158
T5—1,651 m	.86	1.58	1.22	12:10	32	190
T6—2,536 m	.63	1.08	.86	14:00	110	300

water. For example, between 84 m and 631 m, almost all of the surface flow in French Gulch disappeared into the alluvium, but there was no significant change in the Cl concentration (fig. 6). By contrast, downstream from 631 m, a large inflow of water caused the instream Cl concentration to decrease from 3.3 to 0.4 mg/L between 631 m and 744 m. The second characteristic was that the Cl concentrations of inflows between 744 m and 799 m exceeded the instream concentrations. This caused a sharp increase of Cl concentration from 744 to 799 m, and a gradual increase to 1,161 m. These flow characteristics in French Gulch required the use of an independent measure of discharge to prepare a discharge profile of the stream.

#### Spot Injection for Discharge at Selected Sites

To account for these two characteristics of streamflow in French Gulch, spot injections of NaCl tracer were used to obtain instantaneous discharge measurements at sites T2 through T6. Spot injections required the addition of enough tracer to raise the Cl concentration above any Cl from upstream injections (fig. 7). The stream was then sampled for about an hour at a well-mixed point downstream from the spot injection. These injections proved to be the solution to calculating discharge in certain subreaches of the stream.

By knowing the concentration of the injectate and the rate of injection, the discharge at the site can be calculated from the change in concentration measured downstream from the injection.

At site T1, mixing of the tracer into the stream was poor and caused a large overcalculation of discharge (fig. 8). The spot injections were comparable to discharge measurements made with a flow meter at sites T2 and T3. At sites T4 and T6, the calculated discharge from the tracer injection is about 30 percent greater than the discharge measured with a flow meter (Kimball, 1997). This result is expected in mountain streams with cobble bottoms where a large percentage of the streamflow can be among the cobbles of the streambed where it cannot be measured by a flow meter. At site T5, the spot-injection calculation indicated less discharge than the flow-meter measurement. Visible losses and gains of flow occurred all along the stream between sites T4 and T6, so the discharge could have been smaller, but the reason why the flow-meter measurement exceeded the spot-injection calculation is unknown.

Despite the difference in discharge measurements at site T5, most of the lost streamflow appeared to have returned to the stream channel upstream from site T6. Some of the flow could move to the South Branch of French Gulch and appear at site FG-46, but

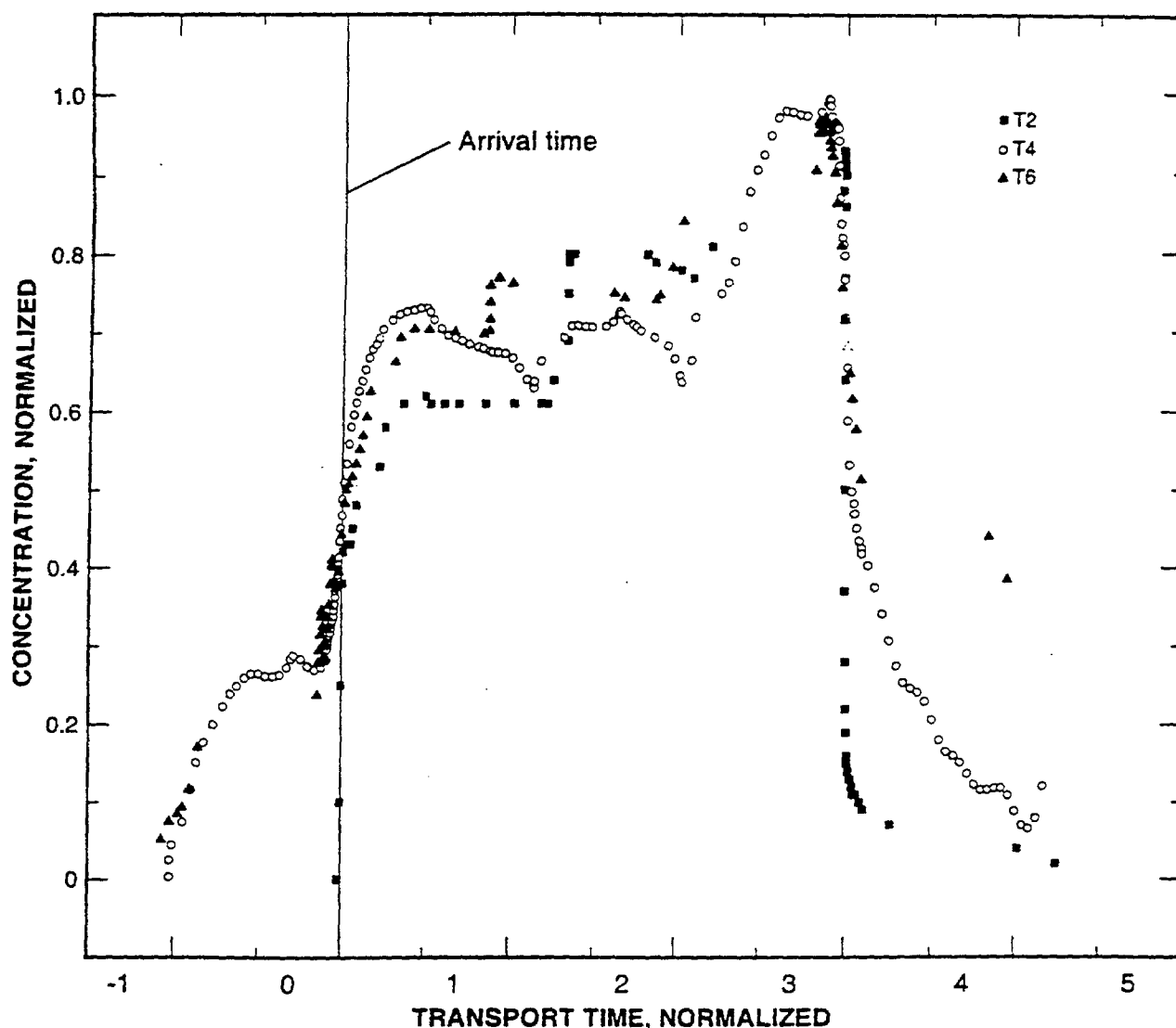


Figure 5. Normalized tracer concentration versus normalized transport time at sites T2, T4, and T6 for the injection period, French Gulch, Colorado.

most of the flow was in the North Branch so that loads could be compared between sites T4 and T6.

By knowing discharge at each of the spot-injection sites, discharge could be calculated for intermediate sites in gaining reaches of French Gulch. Although the reach from sites T2 to T3 had a net gain in flow, the flow nearly disappeared below the surface before much of it was regained from large springs upstream from site T3. This pattern made it impossible to calculate discharge at intermediate sites between T2 and T3. Intermediate discharge was calculated for sampling sites between T3 and T4 by using the spot-injection discharge at site T3 as the first upstream discharge and calculating the next downstream discharge with the equation:

$$Q_d = \frac{Q_u(C_u - C_i)}{(C_d - C_i)} \quad (1)$$

where  $Q_d$  is the downstream discharge,

$Q_u$  is the upstream discharge,

$C_u$  and  $C_d$  are the upstream and downstream tracer concentrations, and

$C_i$  is the inflow concentration.

Thus, the discharge profile was well defined at intermediate points between sites T3 and T4, which includes a critical reach of fault seepage (fig. 9). There also were reliable discharge measurements for sites T2 and T6. Between sites T4 and T6, there was a small, net increase in discharge. Flow along that reach was complex; for calculating mass-balance, this small



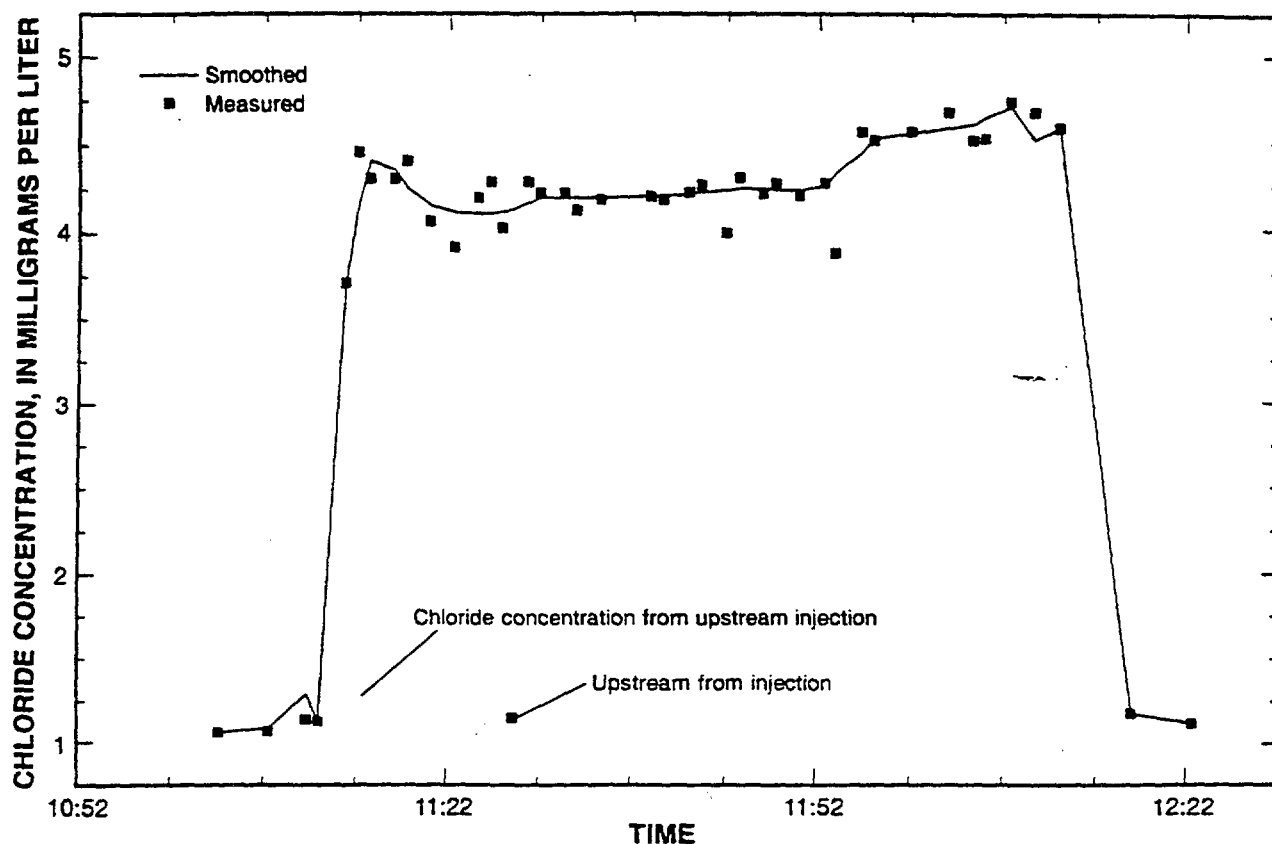


Figure 7. Chloride concentration at site T3 during the spot injection, French Gulch, Colorado

m, these concentrations were diluted by the inflow of the South Branch of French Gulch.

There was a large range of metal concentration among the sampled inflows. The inflow at 1,701 m had the highest concentration of Cd, Mn, and Zn, followed by the inflow at 2,400 m. Both these inflows were a long distance downstream from the 11-10 and Bullhide Faults. Inflows with high concentrations of metals also occurred in the area between the 11-10 and Bullhide Faults at 840 m, 812 m, 814 m, and 857 m. These metal-rich inflows occurred on both sides of the stream.

#### Downstream Profiles of Sulfate and Metals

Mine-related  $\text{SO}_4$  and metals have similar downstream concentration profiles (figs. 10 and 11). These profiles are controlled by the geology and hydrology of French Gulch.

The concentration of  $\text{SO}_4$  in French Gulch ranged from 10.6 mg/L upstream from the mine-affected area to 62 mg/L downstream from the mine-affected area. The range of  $\text{SO}_4$  concentration among inflows was even greater, from 10.8 to 453 mg/L.

Instream  $\text{SO}_4$  concentrations substantially increased in three reaches along the stream (fig. 10). The first increase occurred between 631 and 881 m, where the concentration increased to almost 21 mg/L. This was in the vicinity of the 11-10 Fault (fig. 1) and was likely related to mine drainage from the Wellington-Oro Mine along the fault. The second increase occurred between 2,080 m and 2,200 m, where the concentration increased to about 45 mg/L. This is where the North Branch gained a substantial inflow of metal- and sulfate-rich water that entered the side channel at 1,826 m. Finally, the third increase occurred between 2,388 m and 2,536 m (T6), where the concentration increased to 62 mg/L.

Each of the mine-related metals had concentration profiles similar to that of  $\text{SO}_4$  (fig. 11). The filtered Fe concentration ranged from less than 1  $\mu\text{g/L}$  upstream from the mine-affected area, to 53  $\mu\text{g/L}$  at T6 (2,536 m) downstream from the mine-drainage inflows (fig. 11a). Iron was the most variable of the metals because it precipitates more readily than most metals. The concentration of filtered Cd was low, ranging from

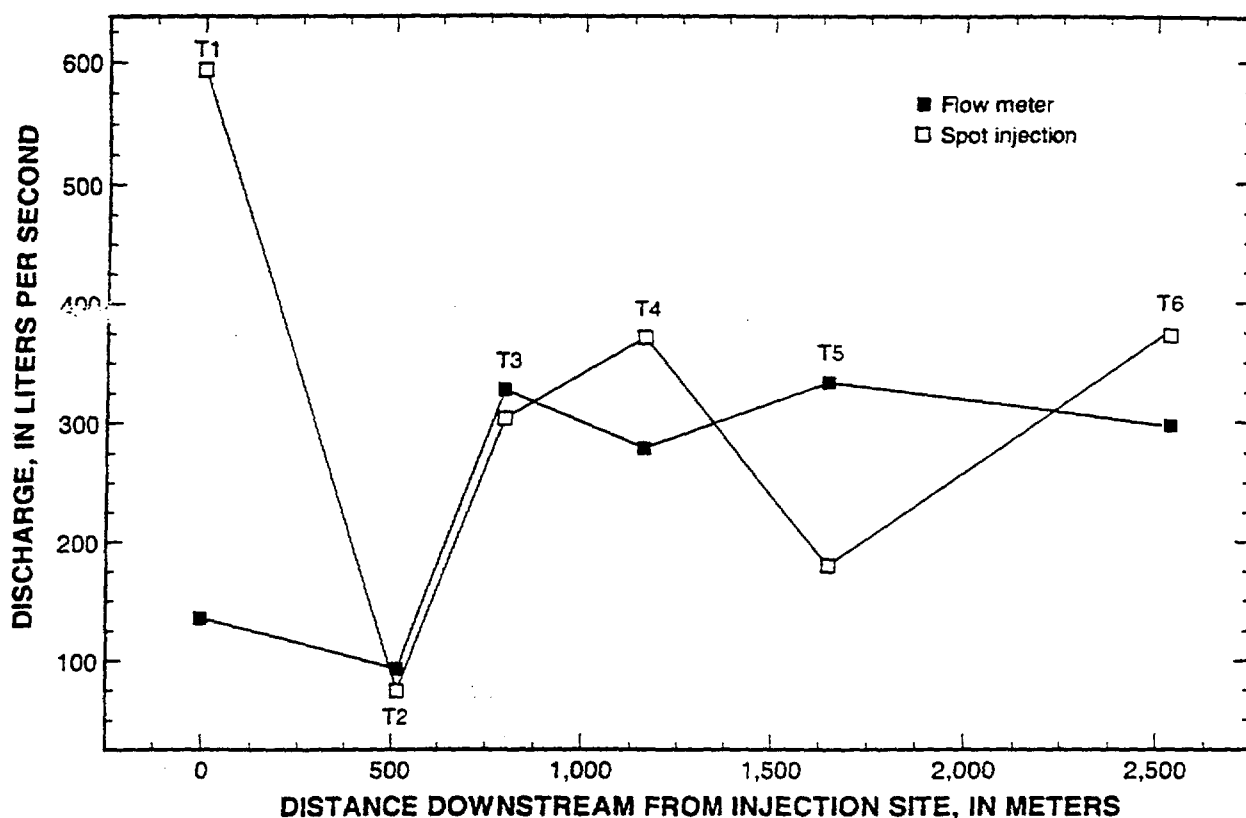


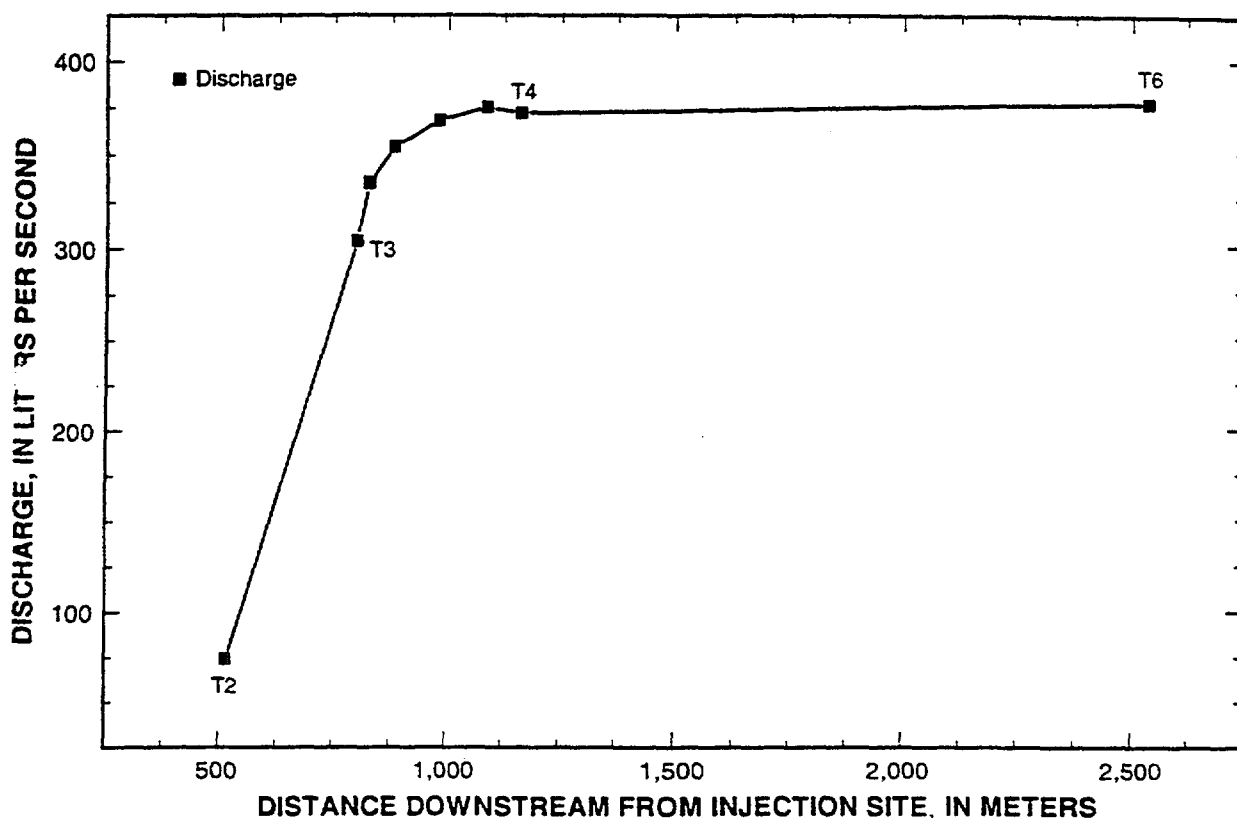
Figure 8. Discharge calculation by spot injection of tracer with discharge measurement by flow meter, French Gulch, Colorado.

less than detection to  $13 \mu\text{g/L}$ , but indicated a very clear increase with distance downstream (fig. 11b). Unlike the other solutes, the increase of filtered Cd was not as great between 2,150 and 2,220 m. The concentration of Cd in the inflows between 819 and 840 m was greater than in the inflows at 1,701 and 2,200 m. The filtered concentration of Mn and Zn (figs. 11c and d) increased at the same inflow locations. The concentration of Mn and Zn was substantially greater than that of Fe and Cd. The concentration of Mn ranged from near  $1 \mu\text{g/L}$  upstream of the mining inflows to about  $1,000 \mu\text{g/L}$  at site T6 (2,536 m). The concentration of filtered Zn ranged from about  $10 \mu\text{g/L}$  upstream of mine-drainage inflows to about  $5,000 \mu\text{g/L}$  at site T6. The Zn that enters the stream could be a cause of fish toxicity in French Gulch.

### Mass-Loading Profiles

The concentration profiles compiled from spatially intensive sampling of stream sites and inflows can be converted into mass-loading profiles. Because

mass-loading profiles take discharge into account, they are more useful than concentration profiles to indicate those reaches of the stream most affected by mine drainage and to evaluate the relative importance of the inflows (fig. 12). Each of the increases in solutes can be quantified as a percentage of the load at the site farthest downstream, site T6. Inflows between 516 m (T2) and 799 m (T3) accounted for 19 percent of the  $\text{SO}_4$  load (fig. 12a). The concentration of  $\text{SO}_4$  in these inflows was low, indicating that the inflows were not affected by mine drainage. The  $\text{SO}_4$ -rich inflows between 799 (T3) and 1,161 m (T4) likely are related to the 11-10 and Bullhide Faults, and accounted for 16 percent of the load. The remaining 65 percent of the load entered the last, broad subreach from 1,161 (T4) to 2,536 m (T6). The largest increases in load likely occurred at 2,150 m and 2,220 m, where the stream gained  $\text{SO}_4$  from surface drainage of the Bullhide Fault. These final inflows to the North Branch are the most significant for adding  $\text{SO}_4$ .



**Figure 9.** Discharge profile calculated from chloride-tracer concentration downstream from the injection site, French Gulch, Colorado.

A different pattern of mass loading occurred for Cd (fig. 12b). Essentially none of the Cd load was added upstream from 799 m (T3). Between 799 m and 1,161 m (T4), however, 66 percent of the downstream load was added, indicating the importance of the 11-10 and Bullhide Faults. Thirty-four percent of the load entered between 1,161 m and 2,536 m (T6). This loading could be proportionally smaller than the loading for Mn and Zn because Cd could have been sorbed onto the abundant Fe oxides that line the bottoms of stream channels where water flows from the Bullhide Fault to inflows at 1,826, 2,400, and 2,422 m.

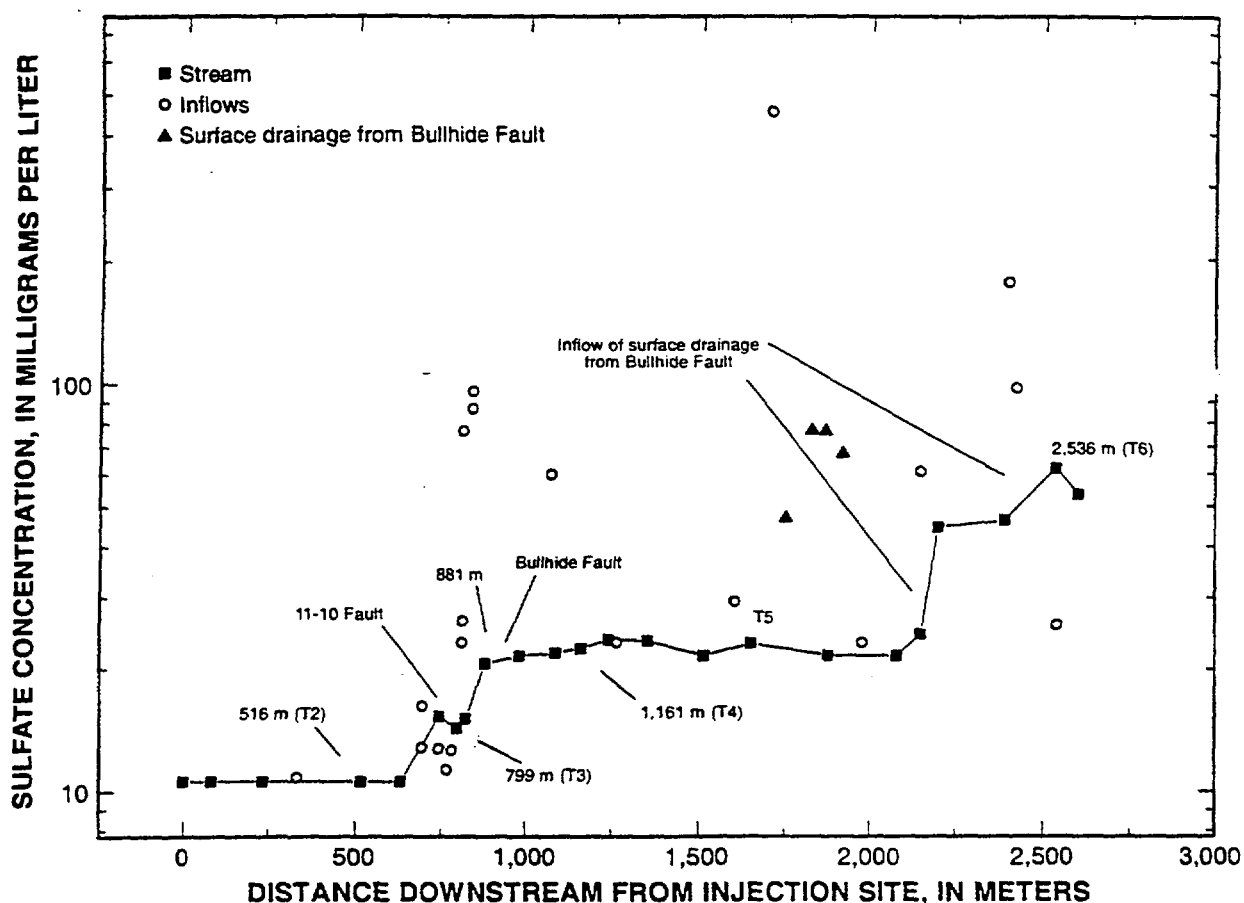
The mass loadings of Mn and Zn were similar to  $\text{SO}_4$  (figs. 12c and 12d). The first significant inflow between 799 m (T3) and 1,161 m (T4) accounted for 26 percent of the Mn load and about 32 percent of the Zn load. The remainder of the Mn and Zn loads entered the North Branch with the inflows at 2,150 and 2,400 m, which drain flow from the Bullhide Fault.

Between 799 m (T3) and 1,161 m (T4), the individual inflows have different effects on the mass loading in each subreach of the stream (fig. 13). For example, the inflows in the first two subreaches, from

799 to 825 m and from 825 to 881 m, caused the instream Zn concentration to increase from 48  $\mu\text{g/L}$  to 368  $\mu\text{g/L}$  and then to 700  $\mu\text{g/L}$ . However, from 881 to 981 m no visible surface inflows occurred and yet the concentration of Zn more than doubled to 1,570  $\mu\text{g/L}$ . The likely cause of this large increase was discharge from the Bullhide Fault, which crosses the stream in that subreach. In the next two subreaches, from 981 to 1,087 m and then from 1,087 m to 1,161 m, again no visible surface inflows occurred and the Zn concentration did not increase. Sulfate, Cd, and Mn concentrations all increased in this same detailed pattern, indicating that discharge from the Bullhide Fault contributes substantially to the instream loads.

### Instream Processes Affecting Metal Transport

The difference between the total recoverable and dissolved concentrations of Fe (fig. 14) indicated that most of the Fe transport was by Fe-rich colloidal particles. The concentration of these colloids in the stream is the difference between the two concentrations. Col-



**Figure 10.** Range of instream and inflow sulfate concentration downstream from the injection site, French Gulch, Colorado.

loids have been shown to have a role in the metal transport of other Rocky Mountain streams affected by mine drainage (Kimball and others, 1992; Kimball and others, 1995; Broshears and others, 1996). Iron colloids are not toxic unless other metals are sorbed to them. Very little of the Zn was transported by the Fe colloids (fig. 14b), but other metals like Cd and Cu generally are associated with Fe colloids (Kimball and others, 1992, table 3). These data indicate that colloidal transport can influence the occurrence and distribution of metals downstream from the mine drainage.

## Summary

Acid mine drainage degrades the water quality and affects the health of fish and other aquatic organisms in French Gulch, Colorado, a stream that drains to the Blue and Colorado Rivers. Metals are present in water that drains abandoned and inactive mines in the watershed. Metals in the water of French Gulch, Colorado, originate from mine drainage in the watershed

and enter the stream in a complex pattern. Among the metals that were found in the water, Zn was likely the most significant as a cause of toxicity. A LiCl tracer injection into the Oro Mine Shaft of the Wellington-Oro Mine did not indicate flowpaths from the upper levels of the mine to the alluvium and the stream. The persistence of the LiCl tracer in the upper part of the Oro Mine Shaft indicated that there was little hydrologic connection with the ground water discharging into the alluvium and affecting the stream. A NaBr injection into an alluvial well was attenuated by ground-water flow in the alluvium, but Br was not detected in water from the downgradient alluvial well or in the stream. When a NaCl tracer injection and synoptic sampling were used, the downstream profile of metal concentrations and mass loading indicates those subreaches of French Gulch where most of the metal loading occurred. There was substantial inflow of metals where the Bullhide Fault crosses the stream. Most of metal load entered French Gulch downstream from the fault at points where, by inference, surface drainage, origi-

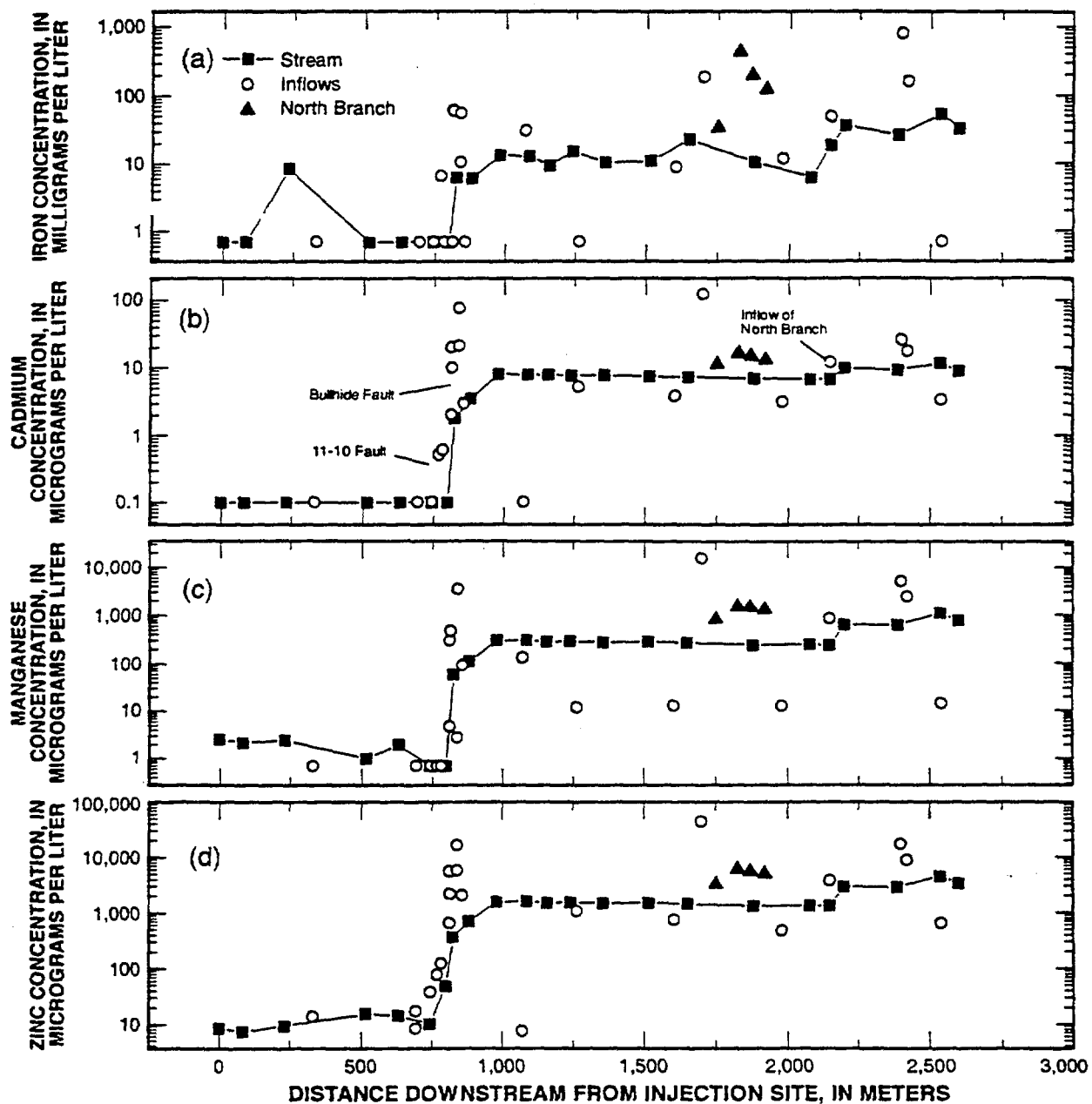
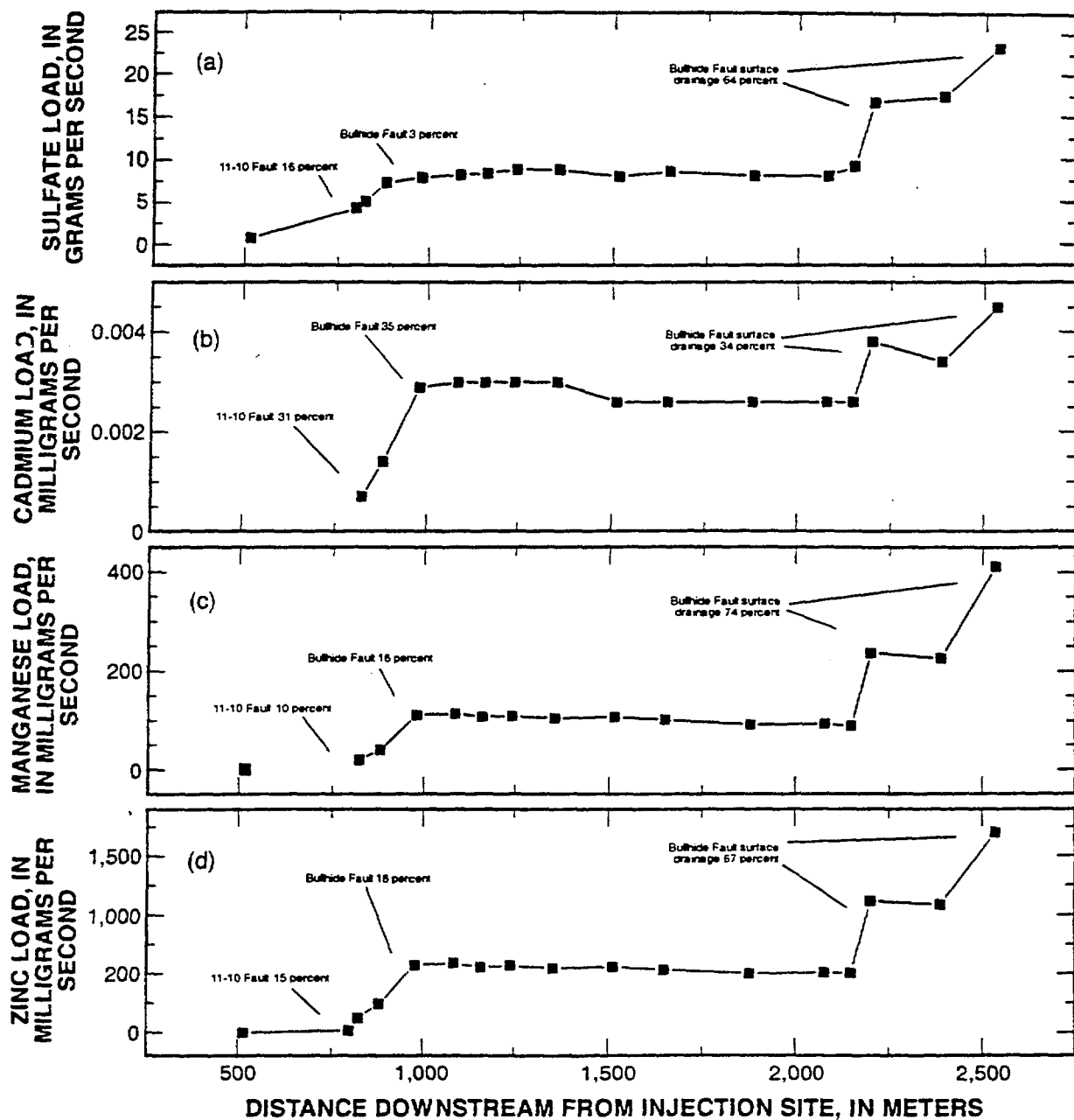
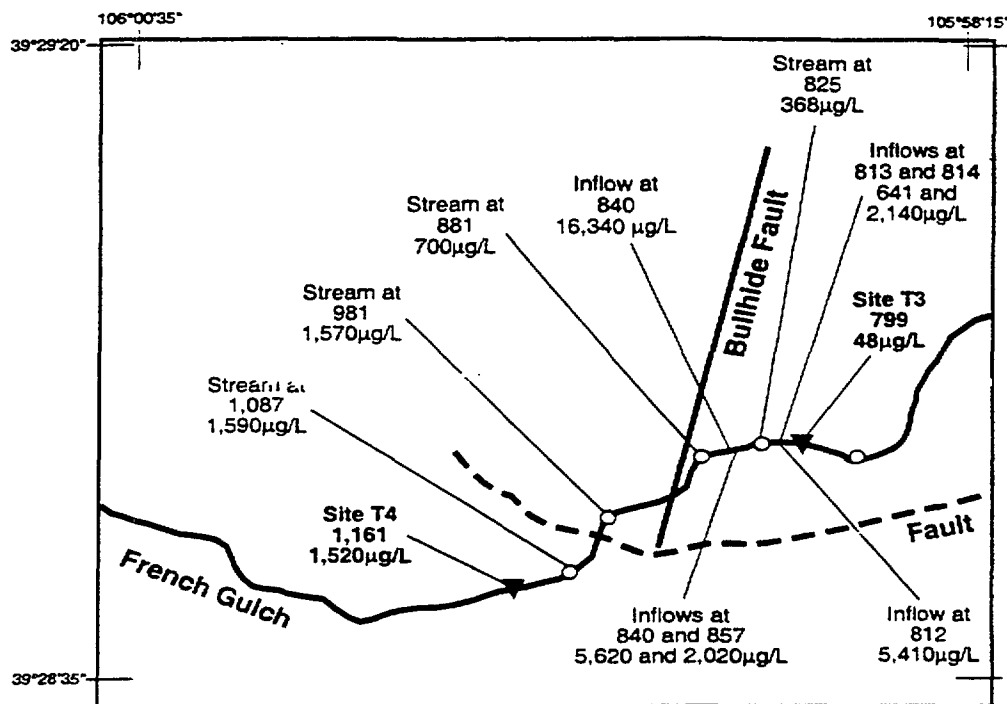


Figure 11. Range of concentrations of (a) iron, (b) cadmium, (c) manganese, and (d) zinc downstream from the injection site, French Gulch, Colorado.



**Figure 12.** Mass-loading profiles for (a) sulfate, (b) cadmium, (c) manganese, and (d) zinc downstream from injection site, French Gulch, Colorado.

**Figure 12.** Mass-loading profiles for (a) sulfate, (b) cadmium, (c) manganese, and (d) zinc downstream from injection site, French Gulch, Colorado.



**Figure 13.** Diagram showing effects of inflows on zinc concentration between sites T3 and T4, French Gulch, Colorado.

**Figure 13.** Effects of inflows on zinc concentration between sites T3 and T4, French Gulch, Colorado.

nating from the Bullhide Fault, entered the North Branch. The largest loading came from springs that are affected by drainage from the Wellington-Oro Mine on the north side of French Gulch. Some of the metal transport was by colloidal Fe oxides, but the extent of that transport needs to be defined in further studies. The loading profiles indicated the importance of the geologic structure on instream metal concentrations and that the stream was mostly affected by mine-pool drainage and inflows of metals where faults cross the stream.

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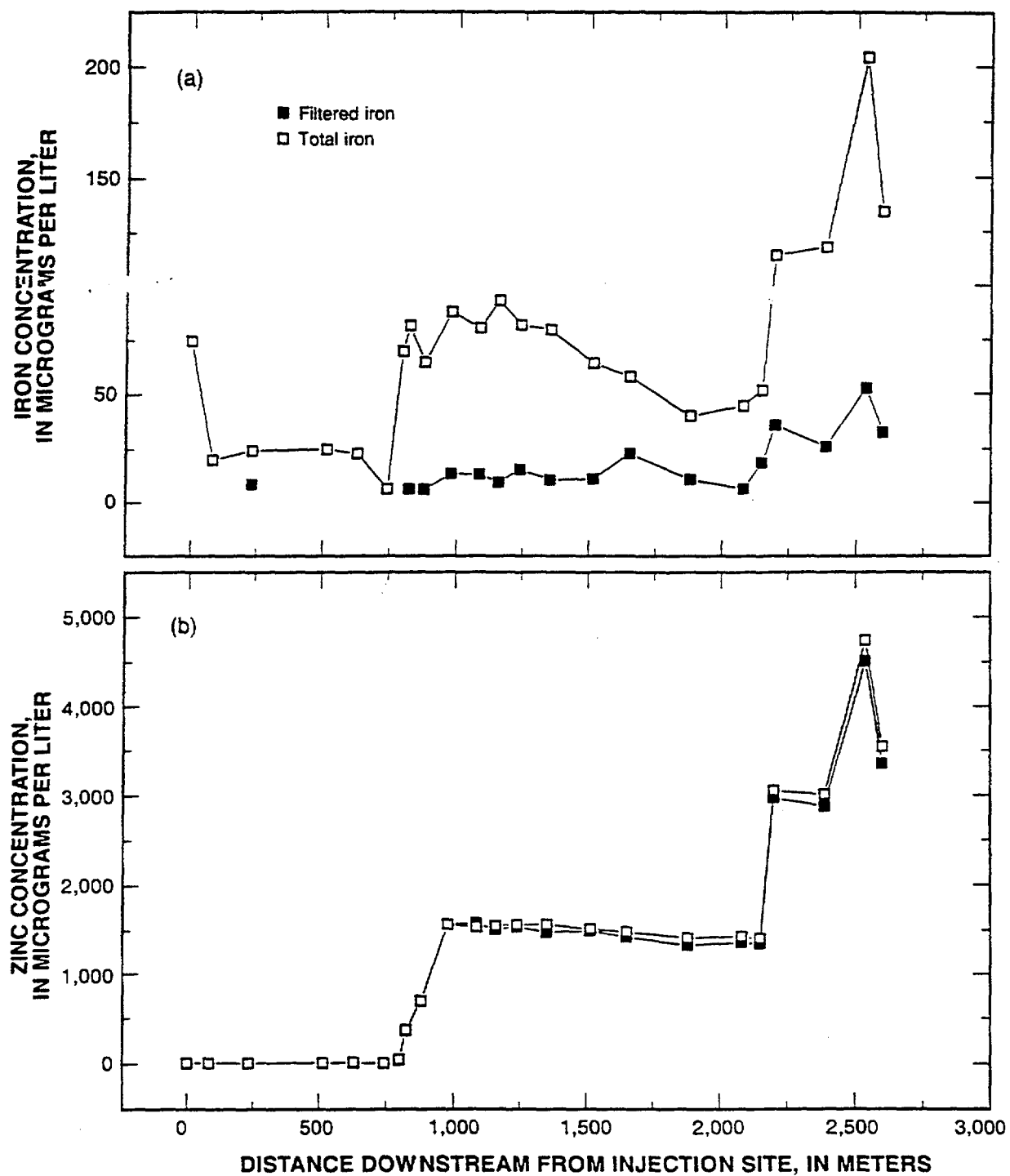


Figure 14. Filtered and total concentrations of (a) iron and (b) zinc downstream from injection site, French Gulch, Colorado.



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**Appendix 1. Concentration of chloride in water from selected wells along French Gulch, Colorado, July 24-28, 1996**

[Concentration in milligrams per liter; <, less than]

Site	Time	Chloride	Site	Time	Chloride
MSRW-3	7/23/96 10:06	2.05	MW-9	7/24/96 11:30	.45
MSRW-3	7/23/96 10:06	< .01	MW-9	7/24/96 12:01	.45
MSRW-3	7/23/96 22:12	2.04	MW-9	7/24/96 12:29	.40
MSRW-3	7/23/96 22:12	2.51	MW-9	7/24/96 13:00	.45
MSRW-3	7/26/96 11:00	2.42	MW-9	7/24/96 13:30	.47
MSRW-3	8/9/96 11:16	2.72	MW-9	7/24/96 14:01	.44
MSRW-3	8/23/96 13:03	2.42	MW-9	7/24/96 14:30	.36
MSRW-3	9/17/96 13:42	1.89	MW-9	7/24/96 15:01	.34
MW-1	7/26/96 11:23	2.14	MW-9	7/24/96 15:29	.40
MW-1	8/9/96 10:53	2.25	MW-9	7/24/96 16:03	.48
MW-1	8/23/96 13:20	1.97	MW-9	7/24/96 16:31	.34
MW-1	9/17/96 13:20	1.24	MW-9	7/24/96 17:03	.46
MW-3	7/26/96 10:17	3.99	MW-9	7/24/96 17:35	.44
MW-3	7/27/96 16:15	3.59	MW-9	7/24/96 18:02	.34
MW-3	7/27/96 16:15	3.63	MW-9	7/24/96 18:30	.36
MW-3	7/27/96 16:15	< .01	MW-9	7/24/96 19:06	.39
MW-3	7/27/96 20:14	3.56	MW-9	7/24/96 19:31	.50
MW-3	7/27/96 20:14	3.65	MW-9	7/24/96 20:22	.46
MW-3	7/27/96 20:14	< .01	MW-9	7/24/96 21:31	.36
MW-3	8/9/96 12:24	3.88	MW-9	7/24/96 22:24	.38
MW-3	8/23/96 13:55	1.25	MW-9	7/24/96 23:10	.48
MW-3	9/17/96 14:20	.95	MW-9	7/25/96 0:26	.34
MW-9	7/23/96 2:25	.36	MW-9	7/25/96 4:23	.54
MW-9	7/23/96 9:32	.39	MW-9	7/25/96 6:26	.42
MW-9	7/23/96 9:42	< .01	MW-9	7/25/96 8:42	.45
MW-9	7/23/96 9:57	< .01	MW-9	7/25/96 9:11	.42
MW-9	7/23/96 10:12	< .01	MW-9	7/25/96 10:31	.45
MW-9	7/23/96 10:27	< .01	MW-9	7/25/96 11:12	.42
MW-9	7/23/96 10:42	< .01	MW-9	7/25/96 12:18	.46
MW-9	7/23/96 10:57	< .01	MW-9	7/25/96 13:14	.43
MW-9	7/23/96 11:13	< .01	MW-9	7/25/96 16:15	.45
MW-9	7/23/96 11:26	< .01	MW-9	7/25/96 17:14	.53
MW-9	7/23/96 11:41	< .01	MW-9	7/25/96 17:20	.47
MW-9	7/23/96 12:00	.44	MW-9	7/25/96 18:12	.44
MW-9	7/23/96 13:00	< .01	MW-9	7/25/96 19:18	.45
MW-9	7/23/96 14:02	2.55	MW-9	7/25/96 20:40	.43
MW-9	7/23/96 14:02	3.69	MW-9	7/25/96 22:40	.44
MW-9	7/23/96 15:04	2.99	MW-9	7/26/96 0:30	.49
MW-9	7/23/96 16:37	1.86	MW-9	7/26/96 2:36	.40
MW-9	7/23/96 18:39	6.17	MW-9	7/26/96 4:28	.44
MW-9	7/23/96 20:27	5.37	MW-9	7/26/96 6:30	.43
MW-9	7/23/96 22:25	3.19	MW-9	7/26/96 8:20	.44
MW-9	7/24/96 0:20	2.18	MW-9	7/26/96 9:09	.44
MW-9	7/24/96 2:15	1.44	MW-9	7/26/96 10:50	.43
MW-9	7/24/96 4:15	.93	MW-9	7/26/96 11:23	.42
MW-9	7/24/96 6:13	.65	MW-9	7/26/96 12:28	.38
MW-9	7/24/96 8:37	.54	MW-9	7/26/96 13:26	.42
MW-9	7/24/96 9:11	.43	MW-9	7/26/96 14:40	.50
MW-9	7/24/96 9:30	.42	MW-9	7/26/96 15:16	.41
MW-9	7/24/96 10:01	.37	MW-9	7/26/96 16:41	.51
MW-9	7/24/96 10:31	.38	MW-9	7/26/96 17:23	.47
MW-9	7/24/96 11:01	.44	MW-9	7/26/96 18:43	.43

Appendix 1. Concentration of chloride in water from selected wells along French Gulch, Colorado, July 24-28, 1996—Continued

Site	Time		Chloride	Site	Time		Chloride
MW-9	7/26/96	19:21	.40	MW-20	7/25/96	10:11	.85
MW-9	7/26/96	20:29	.40	MW-20	7/25/96	12:07	.84
MW-9	7/26/96	22:30	.48	MW-20	7/25/96	16:05	.86
MW-9	7/27/96	0:32	.43	MW-20	7/25/96	17:29	.92
MW-9	7/27/96	2:29	.42	MW-20	7/26/96	2:02	.89
MW-9	7/27/96	4:40	.35	MW-20	7/26/96	4:00	.91
MW-9	7/27/96	4:40	.51	MW-20	7/26/96	5:54	.94
MW-9	7/27/96	6:30	.49	MW-20	7/26/96	6:05	.87
MW-9	7/27/96	8:29	.42	MW-20	7/26/96	9:22	.64
MW-9	7/27/96	9:12	.38	MW-20	7/26/96	9:28	.80
MW-9	7/27/96	10:32	.32	MW-20	7/26/96	13:10	.89
MW-9	7/27/96	10:32	.46	MW-20	7/26/96	15:17	.95
MW-9	7/27/96	11:23	.40	MW-20	7/26/96	16:18	.79
MW-9	7/27/96	12:27	.43	MW-20	7/26/96	17:12	.83
MW-9	7/27/96	13:26	.44	MW-20	7/26/96	20:01	.79
MW-9	7/27/96	14:36	.41	MW-20	7/27/96	0:02	.76
MW-9	7/27/96	15:18	.42	MW-20	7/27/96	2:00	.76
MW-9	7/27/96	17:19	.41	MW-20	7/27/96	4:05	.77
MW-9	7/27/96	18:34	.45	MW-20	7/27/96	6:01	.85
MW-9	7/27/96	19:22	.41	MW-20	7/27/96	9:01	.93
MW-9	7/27/96	20:38	.43	MW-20	7/27/96	10:03	.70
MW-9	7/27/96	22:32	.40	MW-20	7/27/96	11:06	.70
MW-9	7/27/96	22:32	.93	MW-20	7/27/96	16:07	.73
MW-9	7/28/96	0:30	.43	MW-20	7/27/96	17:06	.92
MW-9	7/28/96	2:34	.36	MW-20	7/27/96	20:07	.80
MW-9	7/28/96	2:34	.58	MW-20	7/27/96	22:03	.75
MW-9	7/28/96	4:34	.45	MW-20	7/28/96	0:01	.76
MW-9	7/28/96	6:33	.46	MW-20	7/28/96	2:04	.83
MW-9	7/28/96	9:01	.44	MW-20	7/28/96	4:05	.80
MW-9	8/9/96	12:42	.45	MW-20	7/28/96	6:05	.88
MW-9	8/23/96	14:10	.42	MW-20	7/28/96	8:13	.86
MW-9	9/17/96	11:25	.30	MW-20	8/9/96	11:32	.66
MW-16	7/26/96	11:13	1.73	MW-20	8/23/96	13:35	.64
MW-16	8/9/96	10:40	2.11	MW-20	9/17/96	15:00	.62
MW-16	8/23/96	13:08	1.76	ORO1	7/26/96	9:42	28.18
MW-16	9/17/96	13:10	1.51	ORO1	7/27/96	8:23	38.48
MW-20	7/24/96	10:28	.84	ORO1	7/27/96	8:23	48.66
MW-20	7/24/96	11:26	.84	ORO1	7/27/96	10:26	48.48
MW-20	7/24/96	12:27	.95	ORO1	7/27/96	10:26	60.21
MW-20	7/24/96	14:30	.85	ORO1	7/28/96	0:22	23.39
MW-20	7/24/96	17:33	.86	ORO1	7/28/96	0:22	25.11
MW-20	7/24/96	18:28	1.09	ORO1	7/28/96	0:22	27.27
MW-20	7/24/96	19:23	.93	ORO1	7/28/96	9:13	23.58
MW-20	7/24/96	20:26	.85	ORO1	7/28/96	9:13	25.74
MW-20	7/24/96	23:17	.86	ORO1	7/28/96	9:13	29.57
MW-20	7/25/96	2:01	.82	ORO1	8/9/96	13:00	8.28
MW-20	7/25/96	4:29	.87	ORO1	8/23/96	14:25	28.66
MW-20	7/25/96	9:22	.87	ORO1	9/17/96	10:30	23.55

**Appendix 2. Concentration of chloride and sulfate at selected sites in French Gulch, Colorado, July 24-28, 1996**

[Concentrations are in milligrams per liter; n.v., no value obtained for sample]

Site	Time	Chloride	Sulfate	Site	Time	Chloride	Sulfate
T0	7/24/96 8:55	1.26	9.6	T1	7/24/96 9:35	1.46	9.0
T0	7/24/96 9:15	.08	9.5	T1	7/24/96 9:40	1.03	9.1
T0	7/24/96 9:35	.08	9.6	T1	7/24/96 9:50	.91	9.1
T0	7/24/96 9:55	.09	9.7	T1	7/24/96 9:55	1.14	9.0
T0	7/24/96 11:15	.09	9.5	T1	7/24/96 10:00	1.02	9.6
T0	7/24/96 13:15	.09	9.5	T1	7/24/96 10:15	.77	8.5
T0	7/24/96 15:30	.09	9.6	T1	7/24/96 10:45	1.30	9.0
T0	7/24/96 17:21	.11	9.7	T1	7/24/96 11:00	1.61	8.4
T0	7/24/96 21:02	.09	9.7	T1	7/24/96 11:15	1.03	8.5
T0	7/24/96 22:00	.10	9.6	T1	7/24/96 11:45	1.12	8.4
T0	7/25/96 0:00	.17	9.8	T1	7/24/96 12:00	1.29	9.1
T0	7/25/96 2:05	.09	9.7	T1	7/24/96 13:25	.68	9.1
T0	7/25/96 5:52	.09	10.1	T1	7/24/96 15:34	1.41	8.5
T0	7/25/96 9:43	.09	9.7	T1	7/24/96 18:10	1.16	9.1
T0	7/25/96 12:31	.12	9.8	T1	7/25/96 0:04	.69	8.6
T0	7/25/96 13:26	.10	9.6	T1	7/25/96 1:31	.81	9.1
T0	7/25/96 14:26	.08	9.7	T1	7/25/96 2:12	.84	9.7
T0	7/25/96 15:20	.12	9.8	T1	7/25/96 9:44	.96	11.1
T0	7/25/96 16:26	.09	9.7	T1	7/25/96 15:21	.91	11.0
T0	7/25/96 17:30	.10	9.7	T1	7/25/96 16:29	1.11	11.0
T0	7/26/96 5:03	.09	9.8	T1	7/26/96 4:55	2.79	11.1
T0	7/26/96 5:47	.08	9.7	T1	7/26/96 5:48	1.98	11.1
T0	7/26/96 9:39	.13	10.3	T1	7/26/96 9:42	2.22	11.2
T0	7/26/96 11:30	.10	9.9	T1	7/26/96 11:32	1.70	11.0
T0	7/26/96 14:14	.15	10.1	T1	7/26/96 14:29	.92	9.6
T0	7/27/96 8:11	.10	9.7	T1	7/27/96 8:12	2.44	11.2
T0	7/27/96 15:45	.14	11.2	T1	7/27/96 8:57	3.04	11.3
T0	7/28/96 9:47	.13	11.2	T1	7/27/96 8:58	2.69	11.1
T0	7/28/96 15:33	.13	11.3	T1	7/27/96 9:00	2.47	11.2
T1	7/24/96 8:55	.12	9.1	T1	7/27/96 9:02	.13	11.1
T1	7/24/96 9:00	.02	9.1	T1	7/27/96 9:03	.12	11.1
T1	7/24/96 9:01	1.41	9.1	T1	7/27/96 9:04	.10	11.1
T1	7/24/96 9:02	1.21	9.1	T1	7/27/96 9:05	.10	11.1
T1	7/24/96 9:03	1.39	9.0	T1	7/27/96 9:06	.10	11.1
T1	7/24/96 9:04	.99	8.5	T1	7/27/96 9:07	.10	11.1
T1	7/24/96 9:05	1.30	9.1	T1	7/27/96 9:09	.10	11.0
T1	7/24/96 9:06	1.52	9.1	T1	7/27/96 9:10	.10	11.2
T1	7/24/96 9:07	1.09	8.5	T1	7/27/96 9:11	.10	11.1
T1	7/24/96 9:08	1.30	9.1	T1	7/27/96 9:12	.10	11.1
T1	7/24/96 9:08	.10	11.1	T1	7/27/96 9:13	.14	11.2
T1	7/24/96 9:09	1.38	9.1	T1	7/27/96 9:14	.12	11.2
T1	7/24/96 9:10	1.21	9.1	T1	7/27/96 9:15	.12	11.2
T1	7/24/96 9:11	1.25	8.4	T1	7/27/96 9:16	.11	11.1
T1	7/24/96 9:12	1.29	9.1	T1	7/27/96 9:18	.11	11.1
T1	7/24/96 9:13	1.08	8.5	T1	7/27/96 9:20	.16	11.2
T1	7/24/96 9:14	1.03	8.5	T1	7/27/96 9:22	.11	11.1
T1	7/24/96 9:17	1.34	9.7	T1	7/27/96 9:25	.10	11.1
T1	7/24/96 9:21	1.39	9.1	T1	7/27/96 9:30	.10	11.1
T1	7/24/96 9:23	1.28	9.0	T1	7/27/96 9:35	.20	11.2
T1	7/24/96 9:27	1.10	8.5	T1	7/27/96 9:40	.10	11.1
T1	7/24/96 9:30	.99	8.5	T1	7/27/96 9:50	.10	11.1
T1	7/24/96 9:30	1.00	8.5	T1	7/27/96 10:00	.13	11.2

Appendix 2. Concentration of chloride and sulfate at selected sites in French Gulch, Colorado, July 24-28, 1996—Continued

Site	Time	Chloride	Sulfate	Site	Time	Chloride	Sulfate
T1	7/27/96 10:20	.11	11.2	T2	7/25/96 18:04	10.62	11.0
T1	7/27/96 10:40	.14	11.2	T2	7/25/96 18:08	3.00	9.6
T1	7/27/96 11:00	.10	11.1	T2	7/25/96 18:10	2.82	11.1
T1	7/27/96 11:30	.09	11.2	T2	7/25/96 18:15	2.90	11.1
T1	7/27/96 12:00	.11	11.1	T2	7/26/96 4:52	3.36	9.8
T1	7/27/96 15:47	n.v.	11.2	T2	7/26/96 6:01	3.39	9.8
<del>T1</del>	<del>7/28/96 15:49</del>	<del>.13</del>	<del>11.2</del>	T2	7/26/96 9:51	2.74	11.1
T1	7/28/96 15:33	.14	11.3	T2	7/26/96 9:55	0.65	10.7
T1	7/28/96 15:53	.14	11.3	T2	7/26/96 11:42	2.64	10.5
T1	8/9/96 14:10	.13	12.1	T2	7/26/96 14:22	2.97	9.8
T2	7/24/96 9:00	.07	8.5	T2	7/27/96 9:00	3.65	9.8
T2	7/24/96 9:17	.05	8.1	T2	7/27/96 9:05	3.56	11.0
T2	7/24/96 9:25	1.12	8.5	T2	7/27/96 9:07	3.64	11.0
T2	7/24/96 9:35	1.58	8.5	T2	7/27/96 9:09	3.46	11.0
T2	7/24/96 9:36	1.57	8.4	T2	7/27/96 9:11	3.35	11.2
T2	7/24/96 10:00	1.69	8.5	T2	7/27/96 9:13	3.79	10.7
T2	7/24/96 10:40	1.60	9.0	T2	7/27/96 9:15	3.44	11.0
T2	7/24/96 11:00	1.77	8.4	T2	7/27/96 9:17	3.44	11.1
T2	7/24/96 11:30	1.50	7.9	T2	7/27/96 9:19	3.35	11.9
T2	7/24/96 14:51	2.03	8.7	T2	7/27/96 9:21	3.47	9.9
T2	7/24/96 15:40	2.25	10.4	T2	7/27/96 9:23	2.97	11.0
T2	7/24/96 18:15	2.35	9.8	T2	7/27/96 9:25	2.41	12.1
T2	7/24/96 21:32	2.34	8.6	T2	7/27/96 9:27	1.96	11.9
T2	7/24/96 22:12	2.40	8.6	T2	7/27/96 9:29	1.29	12.0
T2	7/25/96 0:11	2.32	9.8	T2	7/27/96 9:31	1.09	9.8
T2	7/25/96 2:17	2.31	8.6	T2	7/27/96 9:35	.85	10.6
T2	7/25/96 6:04	2.06	10.9	T2	7/27/96 9:40	.74	10.6
T2	7/25/96 10:00	2.38	10.5	T2	7/27/96 9:45	.68	9.8
T2	7/25/96 13:44	2.41	11.8	T2	7/27/96 9:50	.60	11.5
T2	7/25/96 14:40	2.24	10.9	T2	7/27/96 10:00	.57	12.0
T2	7/25/96 15:32	2.37	8.6	T2	7/27/96 10:10	.56	9.8
T2	7/25/96 15:37	10.18	11.2	T2	7/27/96 10:20	.54	10.7
T2	7/25/96 16:06	11.15	11.1	T2	7/27/96 10:30	.48	11.4
T2	7/25/96 16:39	2.41	9.7	T2	7/27/96 10:40	.50	9.9
T2	7/25/96 17:26	10.46	9.6	T2	7/27/96 10:50	.43	11.4
T2	7/25/96 17:32	2.66	11.1	T2	7/27/96 11:00	.45	12.0
T2	7/25/96 17:33	2.87	9.6	T2	7/27/96 11:30	.45	9.9
T2	7/25/96 17:34	2.98	11.0	T2	7/27/96 12:00	.40	11.4
T2	7/25/96 17:35	3.07	11.1	T2	7/27/96 15:50	.30	11.3
T2	7/25/96 17:36	3.45	11.2	T2	7/28/96 9:57	.16	9.8
T2	7/25/96 17:38	10.57	11.1	T2	7/28/96 15:27	.12	9.8
T2	7/25/96 17:39	10.10	11.2	T2	8/9/96 14:00	.14	12.0
T2	7/25/96 17:40	10.42	11.1	T3	7/22/96 9:00	.76	11.1
T2	7/25/96 17:42	10.16	11.1	T3	7/22/96 9:05	.84	11.0
T2	7/25/96 17:44	10.26	11.1	T3	7/23/96 10:35	.52	15.2
T2	7/25/96 17:48	11.28	11.0	T3	7/23/96 10:35	.46	12.8
T2	7/25/96 17:50	11.26	11.0	T3	7/23/96 11:22	.40	13.7
T2	7/25/96 17:52	10.80	9.6	T3	7/23/96 12:54	.44	14.1
T2	7/25/96 17:54	9.95	11.1	T3	7/23/96 13:50	.58	13.7
T2	7/25/96 17:56	10.07	11.1	T3	7/23/96 14:52	.58	14.2
T2	7/25/96 17:58	10.11	11.1	T3	7/23/96 15:54	.64	12.9
T2	7/25/96 18:00	10.09	11.1	T3	7/23/96 17:03	.61	13.9
T2	7/25/96 18:00	2.85	9.6	T3	7/23/96 18:36	.66	14.0
T2	7/25/96 18:02	10.07	11.1	T3	7/23/96 19:36	.73	11.1

Appendix 2. Concentration of chloride and sulfate at selected sites in French Gulch, Colorado, July 24-28, 1996—Continued

Site	Time	Chloride	Sulfate	Site	Time	Chloride	Sulfate
T3	7/23/96 20:36	.69	14.0	T3	7/24/96 21:39	1.27	13.6
T3	7/23/96 21:36	.70	13.9	T3	7/24/96 22:39	1.27	13.6
T3	7/23/96 22:36	.73	14.0	T3	7/24/96 23:39	1.23	13.6
T3	7/23/96 23:36	.75	13.1	T3	7/25/96 1:39	1.21	13.6
T3	7/24/96 0:36	.77	13.6	T3	7/25/96 2:39	1.16	13.6
T3	7/24/96 1:36	.76	13.9	T3	7/25/96 3:39	1.18	13.6
T3	7/24/96 2:36	.80	13.8	T3	7/25/96 4:39	1.16	13.6
T3	7/24/96 3:36	.76	14.0	T3	7/25/96 5:39	1.11	13.6
T3	7/24/96 4:36	.82	14.0	T3	7/25/96 6:39	1.18	13.6
T3	7/24/96 5:36	.78	14.1	T3	7/25/96 7:39	1.15	13.6
T3	7/24/96 6:36	.77	13.8	T3	7/25/96 8:39	1.09	13.5
T3	7/24/96 7:36	.79	13.8	T3	7/25/96 8:39	1.29	13.6
T3	7/24/96 8:36	.80	13.9	T3	7/25/96 10:00	1.09	14.1
T3	7/24/96 9:10	.83	11.2	T3	7/25/96 11:00	1.09	13.9
T3	7/24/96 9:15	.74	13.8	T3	7/25/96 12:00	1.05	13.9
T3	7/24/96 9:20	.76	13.8	T3	7/25/96 13:00	1.03	14.0
T3	7/24/96 9:25	.76	14.1	T3	7/25/96 14:00	1.04	13.1
T3	7/24/96 9:30	.76	10.9	T3	7/25/96 14:51	1.37	15.6
T3	7/24/96 9:35	.80	11.1	T3	7/25/96 14:56	1.00	14.0
T3	7/24/96 9:36	.75	14.0	T3	7/25/96 15:00	1.03	14.2
T3	7/24/96 9:40	.79	11.1	T3	7/25/96 16:00	1.08	13.1
T3	7/24/96 9:45	.82	13.8	T3	7/25/96 16:09	1.01	14.0
T3	7/24/96 9:50	.81	13.9	T3	7/25/96 16:10	1.04	14.0
T3	7/24/96 9:55	.84	14.0	T3	7/25/96 16:11	1.01	14.1
T3	7/24/96 10:00	.84	13.9	T3	7/25/96 16:12	4.67	14.2
T3	7/24/96 10:05	.85	13.8	T3	7/25/96 16:13	4.66	14.1
T3	7/24/96 10:10	.80	13.9	T3	7/25/96 16:14	3.92	14.2
T3	7/24/96 10:15	.86	14.0	T3	7/25/96 16:16	4.80	14.1
T3	7/24/96 10:20	.90	14.0	T3	7/25/96 16:18	4.20	14.1
T3	7/24/96 10:30	.90	11.1	T3	7/25/96 16:20	4.32	14.0
T3	7/24/96 10:35	.96	13.9	T3	7/25/96 16:22	5.15	15.6
T3	7/24/96 10:36	.95	13.0	T3	7/25/96 16:22	3.84	13.2
T3	7/24/96 10:40	.92	14.0	T3	7/25/96 16:24	5.13	15.6
T3	7/24/96 10:45	.96	11.0	T3	7/25/96 16:24	4.22	14.1
T3	7/24/96 10:50	.96	14.0	T3	7/25/96 16:30	2.43	14.3
T3	7/24/96 10:55	1.00	14.2	T3	7/25/96 16:30	5.20	14.0
T3	7/24/96 11:00	.93	11.0	T3	7/25/96 16:30	5.17	14.1
T3	7/24/96 11:15	1.04	14.0	T3	7/25/96 16:30	3.63	14.1
T3	7/24/96 11:30	1.13	11.0	T3	7/25/96 16:30	2.13	13.6
T3	7/24/96 11:45	1.08	11.4	T3	7/25/96 16:34	4.58	14.1
T3	7/24/96 12:00	1.09	14.2	T3	7/25/96 16:36	3.88	14.2
T3	7/24/96 12:20	1.13	14.1	T3	7/25/96 16:37	4.51	14.1
T3	7/24/96 12:40	1.15	11.0	T3	7/25/96 16:38	3.57	13.2
T3	7/24/96 13:00	1.16	14.0	T3	7/25/96 16:40	4.04	14.1
T3	7/24/96 13:20	1.18	11.3	T3	7/25/96 16:43	1.34	15.6
T3	7/24/96 13:40	1.20	11.1	T3	7/25/96 16:45	1.03	13.1
T3	7/24/96 14:00	1.22	14.0	T3	7/25/96 19:04	1.25	13.8
T3	7/24/96 14:30	1.24	11.3	T3	7/25/96 20:04	1.14	13.7
T3	7/24/96 15:00	1.18	11.1	T3	7/25/96 21:04	1.12	13.7
T3	7/24/96 15:30	1.21	11.0	T3	7/25/96 21:15	1.62	25.6
T3	7/24/96 16:00	1.21	11.1	T3	7/25/96 22:04	1.11	13.8
T3	7/24/96 18:39	1.34	13.6	T3	7/25/96 23:04	1.10	13.6
T3	7/24/96 19:39	1.28	13.6	T3	7/26/96 0:04	1.09	13.7
T3	7/24/96 20:37	1.25	13.6	T3	7/26/96 1:04	1.10	13.7

Appendix 2. Concentration of chloride and sulfate at selected sites in French Gulch, Colorado, July 24-28, 1996—Continued

Site	Time	Chloride	Sulfate	Site	Time	Chloride	Sulfate
T3	7/26/96 2:04	1.12	13.7	T3	7/27/96 12:00	.80	13.5
T3	7/26/96 3:33	1.00	14.2	T3	7/27/96 12:20	.70	13.0
T3	7/26/96 4:27	.97	14.2	T3	7/27/96 12:40	.75	13.3
T3	7/26/96 5:04	1.18	14.1	T3	7/27/96 13:00	.67	13.1
T3	7/26/96 5:49	1.06	13.4	T3	7/27/96 15:56	.55	13.6
T3	7/26/96 6:04	1.08	13.7	T3	7/28/96 10:01	.37	13.6
T3	7/26/96 7:04	1.08	13.7	T3	7/28/96 15:19	.36	13.9
T3	7/26/96 8:04	1.07	13.7	T3	8/9/96 13:52	.37	15.4
T3	7/26/96 9:04	1.04	13.7	T3	8/9/96 13:52	.28	14.3
T3	7/26/96 10:04	1.07	14.0	T3	8/23/96 12:35	.27	16.4
T3	7/26/96 11:04	1.12	14.0	T4	7/23/96 11:10	.52	24.4
T3	7/26/96 13:04	1.04	13.8	T4	7/23/96 11:10	.43	21.0
T3	7/26/96 14:04	1.09	13.9	T4	7/23/96 11:32	.47	24.1
T3	7/26/96 17:42	1.07	14.2	T4	7/23/96 13:06	.51	24.1
T3	7/26/96 18:42	1.13	14.3	T4	7/23/96 14:20	.67	24.1
T3	7/26/96 19:42	1.15	14.1	T4	7/23/96 15:00	.73	26.3
T3	7/26/96 20:42	1.24	14.3	T4	7/23/96 16:05	.67	25.2
T3	7/26/96 21:42	1.25	14.3	T4	7/23/96 17:21	.75	24.7
T3	7/26/96 22:42	1.23	13.8	T4	7/23/96 18:47	.87	25.4
T3	7/26/96 23:42	1.25	14.1	T4	7/23/96 19:47	.78	24.9
T3	7/27/96 0:42	1.34	13.9	T4	7/23/96 20:47	.88	25.3
T3	7/27/96 1:42	1.28	14.2	T4	7/23/96 21:47	n.v.	27.0
T3	7/27/96 2:42	1.29	14.1	T4	7/23/96 22:47	.90	25.2
T3	7/27/96 3:42	1.28	14.0	T4	7/23/96 23:47	.91	24.7
T3	7/27/96 4:04	1.11	14.0	T4	7/24/96 0:47	.85	25.3
T3	7/27/96 4:42	1.36	14.3	T4	7/24/96 1:47	.83	24.4
T3	7/27/96 5:42	1.25	14.0	T4	7/24/96 2:47	.85	24.3
T3	7/27/96 5:42	1.29	14.1	T4	7/24/96 3:47	.84	24.5
T3	7/27/96 6:42	1.24	14.1	T4	7/24/96 4:21	1.61	25.1
T3	7/27/96 9:00	1.18	13.5	T4	7/24/96 4:47	.93	23.9
T3	7/27/96 9:05	1.23	13.0	T4	7/24/96 5:47	.87	25.1
T3	7/27/96 9:10	1.20	13.5	T4	7/24/96 6:47	.89	24.6
T3	7/27/96 9:15	1.41	13.4	T4	7/24/96 7:47	.86	25.0
T3	7/27/96 9:20	1.23	13.4	T4	7/24/96 8:47	.85	25.0
T3	7/27/96 9:25	1.32	13.4	T4	7/24/96 9:30	.94	24.2
T3	7/27/96 9:30	1.37	13.4	T4	7/24/96 9:40	.92	24.9
T3	7/27/96 9:35	1.21	13.4	T4	7/24/96 9:47	.95	26.0
T3	7/27/96 9:40	1.31	13.5	T4	7/24/96 9:50	.96	24.4
T3	7/27/96 9:45	1.35	13.4	T4	7/24/96 9:50	.91	24.5
T3	7/27/96 9:50	1.28	13.5	T4	7/24/96 9:56	.93	23.4
T3	7/27/96 9:55	1.25	13.4	T4	7/24/96 10:00	.98	25.3
T3	7/27/96 10:00	1.20	13.5	T4	7/24/96 10:05	.96	25.1
T3	7/27/96 10:05	1.17	13.5	T4	7/24/96 10:10	.98	22.9
T3	7/27/96 10:10	1.16	13.4	T4	7/24/96 10:15	.98	24.2
T3	7/27/96 10:15	1.15	13.0	T4	7/24/96 10:20	.99	24.9
T3	7/27/96 10:20	1.13	13.5	T4	7/24/96 10:25	.98	24.0
T3	7/27/96 10:25	1.21	13.4	T4	7/24/96 10:30	.98	24.8
T3	7/27/96 10:30	1.10	13.5	T4	7/24/96 10:35	1.01	24.9
T3	7/27/96 10:35	1.08	13.4	T4	7/24/96 10:40	1.04	25.1
T3	7/27/96 10:40	1.10	13.4	T4	7/24/96 10:45	1.05	23.5
T3	7/27/96 10:50	1.08	13.4	T4	7/24/96 10:47	.97	24.9
T3	7/27/96 11:00	1.06	13.4	T4	7/24/96 10:50	1.09	24.0
T3	7/27/96 11:20	.96	13.6				
T3	7/27/96 11:40	.92	13.5				

Appendix 2. Concentration of chloride and sulfate at selected sites in French Gulch, Colorado, July 24-28, 1996—Continued

Site	Time	Chloride	Sulfate	Site	Time	Chloride	Sulfate
T4	7/24/96 10:55	1.05	24.9	T4	7/25/96 15:06	4.44	25.5
T4	7/24/96 11:00	1.06	24.2	T4	7/25/96 15:07	4.25	25.4
T4	7/24/96 11:05	1.08	24.6	T4	7/25/96 15:08	4.32	25.3
T4	7/24/96 11:10	1.10	24.5	T4	7/25/96 15:09	4.24	25.4
T4	7/24/96 11:15	1.10	24.4	T4	7/25/96 15:10	4.00	25.2
T4	7/24/96 11:20	1.11	25.2	T4	7/25/96 15:11	4.30	25.2
T4	7/24/96 11:25	1.16	24.5	T4	7/25/96 15:12	4.15	25.3
T4	7/24/96 11:30	1.20	24.6	T4	7/25/96 15:13	n.v.	26.0
T4	7/24/96 11:45	1.27	25.0	T4	7/25/96 15:15	4.41	25.3
T4	7/24/96 11:47	1.13	25.0	T4	7/25/96 15:17	4.20	25.3
T4	7/24/96 12:00	1.28	24.6	T4	7/25/96 15:19	4.17	25.4
T4	7/24/96 12:20	1.33	25.0	T4	7/25/96 15:21	4.28	25.5
T4	7/24/96 12:40	1.33	22.9	T4	7/25/96 15:23	4.13	25.3
T4	7/24/96 13:00	1.39	24.3	T4	7/25/96 15:25	4.19	25.3
T4	7/24/96 13:20	1.38	24.1	T4	7/25/96 15:27	4.36	25.3
T4	7/24/96 13:40	1.41	24.7	T4	7/25/96 15:29	4.17	25.5
T4	7/24/96 14:00	1.49	24.3	T4	7/25/96 15:31	4.55	25.4
T4	7/24/96 14:30	1.48	24.4	T4	7/25/96 15:32	1.50	25.2
T4	7/24/96 15:00	1.50	25.1	T4	7/25/96 16:00	1.46	23.1
T4	7/24/96 15:30	1.56	24.9	T4	7/25/96 19:15	1.72	24.9
T4	7/24/96 16:00	1.57	25.3	T4	7/25/96 20:15	1.62	25.6
T4	7/24/96 16:30	1.53	24.9	T4	7/25/96 21:15	1.58	25.7
T4	7/24/96 17:00	1.55	25.0	T4	7/25/96 22:15	1.60	25.6
T4	7/24/96 17:30	1.61	24.7	T4	7/25/96 23:15	1.59	24.0
T4	7/24/96 18:53	1.61	25.6	T4	7/26/96 1:15	1.57	25.2
T4	7/24/96 19:53	1.66	25.6	T4	7/26/96 2:15	1.63	24.9
T4	7/24/96 20:53	1.63	25.6	T4	7/26/96 3:04	1.11	14.0
T4	7/24/96 21:53	1.61	25.4	T4	7/26/96 3:15	1.65	24.2
T4	7/24/96 22:53	1.61	25.8	T4	7/26/96 3:25	1.67	25.7
T4	7/24/96 23:53	1.62	24.7	T4	7/26/96 4:15	1.57	24.4
T4	7/25/96 0:15	1.56	24.4	T4	7/26/96 5:15	1.56	24.5
T4	7/25/96 0:53	1.63	24.5	T4	7/26/96 5:39	1.57	22.9
T4	7/25/96 1:53	1.56	24.4	T4	7/26/96 6:15	1.63	24.4
T4	7/25/96 2:53	1.62	25.2	T4	7/26/96 8:15	1.56	24.5
T4	7/25/96 3:53	1.51	24.8	T4	7/26/96 10:15	1.54	24.6
T4	7/25/96 4:53	1.51	24.9	T4	7/26/96 11:15	1.51	25.0
T4	7/25/96 5:53	1.61	25.7	T4	7/26/96 12:04	1.07	14.1
T4	7/25/96 7:15	1.55	24.7	T4	7/26/96 12:15	1.73	26.1
T4	7/25/96 7:53	1.52	23.9	T4	7/26/96 13:47	1.22	21.7
T4	7/25/96 8:53	1.52	26.0	T4	7/26/96 14:16	1.62	24.7
T4	7/25/96 9:15	1.55	24.7	T4	7/26/96 18:03	1.57	25.5
T4	7/25/96 9:53	1.50	25.9	T4	7/26/96 19:03	1.63	25.6
T4	7/25/96 10:00	1.55	25.3	T4	7/26/96 20:03	1.65	25.4
T4	7/25/96 11:00	1.53	22.6	T4	7/26/96 21:03	1.75	25.8
T4	7/25/96 12:00	1.49	24.6	T4	7/26/96 22:03	1.88	26.1
T4	7/25/96 13:00	1.52	24.6	T4	7/26/96 23:03	1.83	25.5
T4	7/25/96 14:00	1.46	23.5	T4	7/27/96 0:03	1.87	25.5
T4	7/25/96 14:59	1.48	25.3	T4	7/27/96 1:03	1.96	25.8
T4	7/25/96 15:00	1.46	25.3	T4	7/27/96 2:03	1.91	25.5
T4	7/25/96 15:00	1.50	25.4	T4	7/27/96 3:03	1.92	25.6
T4	7/25/96 15:02	1.47	25.4	T4	7/27/96 4:03	1.97	25.2
T4	7/25/96 15:03	4.29	25.2	T4	7/27/96 5:03	1.89	25.4
T4	7/25/96 15:04	4.48	25.2	T4	7/27/96 6:03	1.92	25.6
T4	7/25/96 15:05	4.16	25.4	T4	7/27/96 8:03	1.87	25.1



Appendix 2. Concentration of chloride and sulfate at selected sites in French Gulch, Colorado, July 24-28, 1996—Continued

Site	Time		Chloride	Sulfate	Site	Time		Chloride	Sulfate
T4	7/27/96	9:00	1.96	25.8	T4	7/28/96	7:53	.60	25.7
T4	7/27/96	9:03	2.02	25.8	T4	7/28/96	8:53	.67	25.3
T4	7/27/96	9:10	2.01	25.7	T4	7/28/96	9:53	.63	25.5
T4	7/27/96	9:20	1.96	25.9	T4	7/28/96	10:53	.62	25.1
T4	7/27/96	9:30	2.02	25.9	T4	7/28/96	11:53	.58	25.6
T4	7/27/96	9:35	1.98	26.0	T4	7/28/96	12:53	.54	25.2
T4	7/27/96	9:40	1.98	26.0	T4	7/28/96	13:53	.55	25.9
T4	7/27/96	9:45	1.90	25.8	T4	7/28/96	14:53	.54	25.7
T4	7/27/96	9:50	1.96	26.0	T4	7/28/96	15:53	.63	25.9
T4	7/27/96	9:55	1.95	25.9	T4	8/9/96	13:45	.36	23.9
T4	7/27/96	10:00	1.99	26.1	T4	8/23/96	12:25	.33	24.3
T4	7/27/96	10:03	1.97	26.0	T4	9/17/96	14:50	.14	23.3
T4	7/27/96	10:05	1.99	26.2	T4A	7/25/96	15:35	4.50	25.4
T4	7/27/96	10:10	1.97	25.9	T4C	7/25/96	15:35	4.51	25.4
T4	7/27/96	10:15	1.85	25.7	T4D	7/25/96	15:35	4.00	25.5
T4	7/27/96	10:20	1.97	26.2	T5	7/21/96	11:50	1.12	24.9
T4	7/27/96	10:25	1.93	26.5	T5	7/22/96	10:00	.86	25.0
T4	7/27/96	10:30	1.97	26.9	T5	7/23/96	11:53	.49	24.6
T4	7/27/96	10:35	1.97	27.0	T5	7/23/96	13:18	.54	25.2
T4	7/27/96	10:40	1.89	26.8	T5	7/23/96	14:33	.60	24.1
T4	7/27/96	10:50	1.77	27.0	T5	7/23/96	15:13	.69	24.4
T4	7/27/96	11:00	1.73	26.8	T5	7/23/96	16:15	.71	25.1
T4	7/27/96	11:10	1.71	27.4	T5	7/23/96	17:29	.71	24.7
T4	7/27/96	11:20	1.76	27.6	T5	7/23/96	18:58	.74	25.0
T4	7/27/96	11:30	1.76	27.2	T5	7/23/96	19:58	.87	24.8
T4	7/27/96	11:30	1.63	27.7	T5	7/23/96	20:58	.80	25.1
T4	7/27/96	11:40	1.64	27.8	T5	7/23/96	21:58	.81	24.9
T4	7/27/96	12:00	1.36	27.0	T5	7/23/96	22:58	.90	24.8
T4	7/27/96	12:03	1.45	27.9	T5	7/23/96	23:58	.89	25.0
T4	7/27/96	12:20	1.23	27.0	T5	7/24/96	0:58	.82	24.4
T4	7/27/96	12:40	1.21	27.2	T5	7/24/96	1:43	1.15	20.2
T4	7/27/96	13:00	1.20	27.8	T5	7/24/96	1:58	.87	25.4
T4	7/27/96	13:03	1.23	27.7	T5	7/24/96	2:58	.87	25.1
T4	7/27/96	13:20	1.16	27.5	T5	7/24/96	3:58	.89	25.1
T4	7/27/96	13:40	1.14	27.5	T5	7/24/96	4:58	.87	25.0
T4	7/27/96	14:00	1.10	27.7	T5	7/24/96	5:58	.91	24.9
T4	7/27/96	14:03	1.12	27.4	T5	7/24/96	6:58	.89	25.1
T4	7/27/96	14:53	1.08	26.3	T5	7/24/96	7:58	.86	25.2
T4	7/27/96	15:53	1.04	26.4	T5	7/24/96	8:58	.89	25.0
T4	7/27/96	16:53	.98	26.0	T5	7/24/96	9:58	.86	25.0
T4	7/27/96	17:53	.95	26.1	T5	7/24/96	10:20	.92	25.1
T4	7/27/96	18:53	.79	25.7	T5	7/24/96	10:40	.95	25.2
T4	7/27/96	19:53	.88	26.1	T5	7/24/96	11:00	.98	24.8
T4	7/27/96	20:53	.80	26.1	T5	7/24/96	11:05	1.02	24.9
T4	7/27/96	21:53	.90	26.8	T5	7/24/96	11:10	1.11	25.1
T4	7/27/96	22:53	.76	26.2	T5	7/24/96	11:15	1.02	24.7
T4	7/27/96	23:53	.87	25.9	T5	7/24/96	11:20	1.04	24.8
T4	7/28/96	0:53	.66	25.6	T5	7/24/96	11:25	1.02	25.0
T4	7/28/96	1:53	.74	25.7	T5	7/24/96	11:30	1.11	24.8
T4	7/28/96	2:53	.66	25.6	T5	7/24/96	11:35	1.12	25.0
T4	7/28/96	3:53	.76	25.6	T5	7/24/96	11:40	1.14	25.1
T4	7/28/96	4:53	.68	25.6	T5	7/24/96	11:45	1.10	25.1
T4	7/28/96	5:53	.60	25.5	T5	7/24/96	11:55	1.16	24.6
T4	7/28/96	6:53	.63	25.7	T5	7/24/96	12:00	1.22	25.2

Appendix 2. Concentration of chloride and sulfate at selected sites in French Gulch, Colorado, July 24-28, 1996—Continued

Site	Time	Chloride	Sulfate	Site	Time	Chloride	Sulfate
T5	7/24/96 12:10	1.25	25.4	T5	7/26/96 2:28	1.66	25.1
T5	7/24/96 12:20	1.39	24.8	T5	7/26/96 3:15	1.64	26.2
T5	7/24/96 12:30	1.27	25.0	T5	7/26/96 3:28	1.63	25.7
T5	7/24/96 12:45	1.36	25.3	T5	7/26/96 4:12	1.56	25.6
T5	7/24/96 13:00	1.37	25.3	T5	7/26/96 4:28	1.60	26.2
T5	7/24/96 13:15	1.40	25.0	T5	7/26/96 5:24	1.58	26.0
T5	7/24/96 13:30	1.42	25.1	T5	7/26/96 5:28	1.59	26.4
T5	7/24/96 13:45	1.44	25.0	T5	7/26/96 6:28	1.63	25.3
T5	7/24/96 14:00	1.47	25.0	T5	7/26/96 7:28	1.61	24.8
T5	7/24/96 14:30	1.47	25.8	T5	7/26/96 8:28	1.62	25.1
T5	7/24/96 15:00	1.48	25.5	T5	7/26/96 9:28	1.61	25.2
T5	7/24/96 15:30	1.47	25.3	T5	7/26/96 10:28	1.64	26.1
T5	7/24/96 16:00	1.50	25.6	T5	7/26/96 11:28	1.59	26.0
T5	7/24/96 16:30	1.70	25.0	T5	7/26/96 12:28	1.56	25.7
T5	7/24/96 17:00	1.61	25.5	T5	7/26/96 13:08	1.58	25.2
T5	7/24/96 17:30	1.62	25.7	T5	7/26/96 17:23	1.72	25.8
T5	7/24/96 18:00	1.71	25.0	T5	7/26/96 17:43	1.19	22.3
T5	7/24/96 20:05	1.59	25.7	T5	7/26/96 18:43	1.69	25.8
T5	7/25/96 10:00	1.48	25.2	T5	7/26/96 18:43	1.28	22.4
T5	7/25/96 11:00	1.50	25.4	T5	7/26/96 19:43	1.74	25.8
T5	7/25/96 12:00	1.47	25.1	T5	7/26/96 19:43	1.32	22.3
T5	7/25/96 13:00	1.52	25.2	T5	7/26/96 20:43	1.81	25.9
T5	7/25/96 13:32	1.45	24.4	T5	7/26/96 20:43	1.32	22.2
T5	7/25/96 13:33	1.47	24.4	T5	7/26/96 21:43	1.09	20.5
T5	7/25/96 13:34	1.45	25.2	T5	7/26/96 22:43	1.14	20.7
T5	7/25/96 13:35	6.77	25.0	T5	7/26/96 23:43	1.14	20.6
T5	7/25/96 13:36	6.49	24.7	T5	7/27/96 0:43	1.22	20.4
T5	7/25/96 13:37	6.10	24.4	T5	7/27/96 2:43	1.41	21.8
T5	7/25/96 13:38	6.23	24.3	T5	7/27/96 3:43	1.26	20.5
T5	7/25/96 13:40	6.43	24.3	T5	7/27/96 3:43	1.40	21.8
T5	7/25/96 13:42	6.76	25.0	T5	7/27/96 4:43	1.21	20.6
T5	7/25/96 13:46	6.58	25.5	T5	7/27/96 6:43	1.20	20.4
T5	7/25/96 13:48	6.13	24.6	T5	7/27/96 7:03	2.00	25.6
T5	7/25/96 13:50	6.53	25.3	T5	7/27/96 7:43	1.33	20.5
T5	7/25/96 13:52	6.16	24.5	T5	7/27/96 8:43	1.40	21.8
T5	7/25/96 13:56	6.50	25.3	T5	7/27/96 9:30	2.28	26.2
T5	7/25/96 13:58	6.60	25.3	T5	7/27/96 9:40	2.10	26.2
T5	7/25/96 14:00	1.53	26.3	T5	7/27/96 9:43	1.53	22.1
T5	7/25/96 14:00	6.19	24.7	T5	7/27/96 9:45	2.09	26.1
T5	7/25/96 14:02	6.75	25.4	T5	7/27/96 9:50	2.03	25.9
T5	7/25/96 14:06	1.49	25.2	T5	7/27/96 9:55	1.99	25.7
T5	7/25/96 14:10	1.45	25.1	T5	7/27/96 10:00	2.04	26.2
T5	7/25/96 14:15	1.45	25.3	T5	7/27/96 10:05	2.03	26.1
T5	7/25/96 15:00	1.42	25.6	T5	7/27/96 10:10	2.05	25.8
T5	7/25/96 16:00	1.56	26.1	T5	7/27/96 10:15	2.04	25.6
T5	7/25/96 18:28	1.51	25.3	T5	7/27/96 10:20	2.04	26.1
T5	7/25/96 19:28	1.78	25.4	T5	7/27/96 10:25	2.00	26.4
T5	7/25/96 20:28	1.76	26.1	T5	7/27/96 10:30	2.09	26.3
T5	7/25/96 21:28	1.78	25.5	T5	7/27/96 10:35	2.03	25.9
T5	7/25/96 22:28	1.65	25.1	T5	7/27/96 10:40	2.04	26.3
T5	7/25/96 23:28	1.63	25.2	T5	7/27/96 10:43	1.37	22.6
T5	7/26/96 0:28	1.67	25.1	T5	7/27/96 10:45	1.97	26.5
T5	7/26/96 1:28	1.57	25.0	T5	7/27/96 10:50	1.98	26.8
T5	7/26/96 2:26	1.63	26.3	T5	7/27/96 10:55	1.89	26.2

Appendix 2. Concentration of chloride and sulfate at selected sites in French Gulch, Colorado, July 24-28, 1996—Continued

Site	Time	Chloride	Sulfate	Site	Time	Chloride	Sulfate
T5	7/27/96 11:00	1.93	26.7	T6	7/24/96 17:00	1.03	65.6
T5	7/27/96 11:20	1.78	26.9	T6	7/24/96 17:30	.95	64.6
T5	7/27/96 11:40	1.80	27.6	T6	7/24/96 18:00	.98	64.0
T5	7/27/96 11:43	1.06	21.9	T6	7/24/96 21:40	1.09	55.8
T5	7/27/96 12:00	1.46	27.6	T6	7/24/96 22:20	1.07	55.3
T5	7/27/96 12:20	1.47	28.0	T6	7/25/96 0:18	1.08	55.0
T5	7/27/96 12:20	1.37	27.8	T6	7/25/96 2:29	1.09	55.6
T5	7/27/96 13:00	1.35	27.8	T6	7/25/96 6:11	1.06	55.0
T5	7/27/96 13:20	1.23	27.7	T6	7/25/96 10:19	1.18	58.6
T5	7/27/96 13:40	1.20	28.9	T6	7/25/96 11:04	1.06	71.2
T5	7/27/96 14:00	1.17	27.5	T6	7/25/96 11:08	1.07	59.0
T5	7/27/96 14:30	1.08	27.1	T6	7/25/96 11:11	1.14	58.4
T5	7/27/96 15:00	1.10	27.0	T6	7/25/96 11:12	1.13	57.7
T5	7/27/96 16:05	.94	26.3	T6	7/25/96 11:14	3.71	58.0
T5	7/28/96 10:13	.55	24.9	T6	7/25/96 11:15	4.46	60.0
T5	7/28/96 15:11	.55	25.8	T6	7/25/96 11:16	4.31	58.4
T5	8/23/96 12:15	.32	24.1	T6	7/25/96 11:18	4.31	58.6
T6	7/23/96 12:23	.45	58.0	T6	7/25/96 11:19	4.41	59.4
T6	7/23/96 13:31	.63	68.7	T6	7/25/96 11:21	4.07	60.7
T6	7/23/96 14:42	.40	62.1	T6	7/25/96 11:23	3.92	59.4
T6	7/23/96 15:24	.50	61.5	T6	7/25/96 11:25	4.20	60.1
T6	7/23/96 16:23	.47	65.3	T6	7/25/96 11:26	4.29	60.0
T6	7/23/96 17:37	.56	64.0	T6	7/25/96 11:27	4.03	58.3
T6	7/24/96 10:30	.94	63.5	T6	7/25/96 11:28	1.15	70.4
T6	7/24/96 10:40	.66	56.7	T6	7/25/96 11:29	4.29	58.0
T6	7/24/96 10:50	.69	59.0	T6	7/25/96 11:30	4.23	58.6
T6	7/24/96 11:00	.65	55.5	T6	7/25/96 11:32	4.23	58.4
T6	7/24/96 11:05	.74	55.9	T6	7/25/96 11:33	4.13	60.0
T6	7/24/96 11:10	.74	56.0	T6	7/25/96 11:35	4.19	58.1
T6	7/24/96 11:15	.73	56.4	T6	7/25/96 11:39	4.21	58.3
T6	7/24/96 11:20	.72	56.0	T6	7/25/96 11:40	4.19	58.3
T6	7/24/96 11:25	.63	57.1	T6	7/25/96 11:42	4.23	58.6
T6	7/24/96 11:30	.68	56.8	T6	7/25/96 11:43	4.27	58.8
T6	7/24/96 11:35	.67	56.7	T6	7/25/96 11:45	4.00	60.0
T6	7/24/96 11:40	.68	58.5	T6	7/25/96 11:46	1.10	69.5
T6	7/24/96 11:45	.67	58.1	T6	7/25/96 11:46	4.31	58.5
T6	7/24/96 11:50	.73	57.7	T6	7/25/96 11:48	4.22	58.9
T6	7/24/96 11:55	.63	58.5	T6	7/25/96 11:49	4.28	60.4
T6	7/24/96 12:00	.74	58.7	T6	7/25/96 11:51	4.21	60.2
T6	7/24/96 12:10	.75	57.8	T6	7/25/96 11:53	4.28	58.3
T6	7/24/96 12:20	.71	58.3	T6	7/25/96 11:54	3.88	56.5
T6	7/24/96 12:30	1.06	70.7	T6	7/25/96 11:56	4.57	58.8
T6	7/24/96 12:40	.80	59.8	T6	7/25/96 11:57	4.52	58.3
T6	7/24/96 12:50	.81	59.7	T6	7/25/96 11:58	1.14	71.4
T6	7/24/96 13:00	.76	64.4	T6	7/25/96 12:00	4.57	58.4
T6	7/24/96 13:20	.75	62.7	T6	7/25/96 12:03	4.68	59.3
T6	7/24/96 13:40	.74	59.7	T6	7/25/96 12:05	4.52	58.5
T6	7/24/96 14:00	.85	64.9	T6	7/25/96 12:06	4.53	58.8
T6	7/24/96 14:20	.92	62.9	T6	7/25/96 12:08	4.74	58.5
T6	7/24/96 14:40	.89	65.6	T6	7/25/96 12:10	4.68	58.5
T6	7/24/96 15:00	.84	61.9	T6	7/25/96 12:12	1.22	65.9
T6	7/24/96 15:30	.89	63.8	T6	7/25/96 12:12	4.59	61.1
T6	7/24/96 16:00	.97	64.4	T6	7/25/96 12:18	1.18	59.4
T6	7/24/96 16:30	.90	65.3	T6	7/25/96 12:23	1.12	61.8

Appendix 2. Concentration of chloride and sulfate at selected sites in French Gulch, Colorado, July 24-28, 1996—Continued

Site	Time	Chloride	Sulfate	Site	Time	Chloride	Sulfate
T6	7/25/96 14:20	1.29	59.9	T6	7/27/96 11:00	1.35	60.4
T6	7/25/96 15:50	1.83	59.6	T6	7/27/96 11:10	1.29	60.6
T6	7/26/96 4:43	1.12	66.7	T6	7/27/96 11:30	1.32	61.2
T6	7/26/96 6:13	1.13	66.3	T6	7/27/96 11:40	1.35	60.9
T6	7/26/96 10:49	1.11	58.4	T6	7/27/96 11:50	1.30	61.4
T6	7/26/96 11:20	1.31	60.9	T6	7/27/96 12:00	1.30	62.3
T6	7/26/96 13:09	1.10	62.7	T6	7/27/96 12:20	1.27	64.1
T6	7/26/96 14:44	1.12	62.8	T6	7/27/96 12:40	1.27	63.5
T6	7/27/96 9:40	1.36	60.9	T6	7/27/96 13:20	1.18	64.4
T6	7/27/96 10:00	1.35	60.4	T6	7/27/96 13:40	1.13	65.0
T6	7/27/96 10:05	1.32	60.9	T6	7/27/96 14:00	1.09	67.0
T6	7/27/96 10:10	1.36	60.7	T6	7/27/96 14:20	1.07	66.1
T6	7/27/96 10:15	1.31	60.8	T6	7/27/96 14:40	1.04	65.7
T6	7/27/96 10:20	1.33	60.6	T6	7/27/96 15:00	.97	65.8
T6	7/27/96 10:25	1.31	60.7	T6	7/27/96 15:30	.95	66.9
T6	7/27/96 10:30	1.36	61.3	T6	7/27/96 16:12	1.34	81.5
T6	7/27/96 10:35	1.33	60.7	T6	7/28/96 10:14	.82	73.1
T6	7/27/96 10:40	1.32	60.9	T6	7/28/96 13:00	.79	74.0
T6	7/27/96 10:45	1.37	60.3	T6	8/9/96 13:24	.50	81.1
T6	7/27/96 10:50	1.33	60.7	T6	8/23/96 12:00	.44	86.3
T6	7/27/96 10:55	1.36	60.7	T6	9/17/96 15:40	.35	87.7

**Appendix 3. Site description and physical properties of water from synoptic sampling sites, French Gulch, Colorado, July 26, 1996**

[Site, field identification label; Distance, downstream from injection, in meters; Temp, temperature, in degrees Celsius; pH, in log units; Cond, specific conductance, in microsiemens per centimeter at 25 degrees Celsius; Q, discharge from tracer calculations, in liters per second; Qmeter, discharge from flow-meter measurement, in liters per second; RB, right bank; LB, left bank]

Site	Distance	Description of site	Temp	pH	Cond	Q	Qmeter
<b>Stream sites</b>							
FG00	0	Injection point; Site T0 just upstream from injection	10.5	8.23	84		136.0
FG03	84	Along straight portion of stream	11.0	8.6	101		
FG05	234	Along straight portion of stream	11.0	8.9	98		
TS02	516	Site T2 (State site FG5)	11.0	7.32	98	74.2	93.4
FG09	631	Flag on RB at downstream end of willows, channel is about 35 feet wide	11.5	8.38	100		
FG09d	744	End of culvert at Country Boy Road	5.5	6.7	109		
TS03	799	Site T3; stream at top of cascade; ISCO site	7.0	7.36	108	304.0	328.0
FG17b	825	Stream site added to see effect of FG16-b&c; distance estimated	7.0	7.81	112	334.6	
FG18	881	Stream; at bottom of steep rock hill	8.0	8.06	131	354.0	
FG25	981	Old FG25 was inflow that is now dry; this is stream site to replace FG24	9.0	7.74	136	368.0	
FG28	1,087	Stream near white semi trailer	7.0	7.71	135	375.0	
TS04	1,161	Site T4; stream below culvert; ISCO site	7.0	7.74	135	372.0	279.0
FG31	1,242	By big cut in alluvium with foot bridge (pole across stream)	7.0	7.53	138		
FG33	1,356	Downstream from triple power pole	8.0	7.70	137		
FG35	1,515	Before double power poles	7.5	7.61	135		
TS05	1,651	Site T5; below inflow area; ISCO Site	10.0	7.35	138	179.7	334.0
FG39	1,751	Above split of north branch to ponded area	9.0	7.17	192		
FG50	1,880	Wide gravel bar; north branch, first site downstream from FG39	8.5	7.27	137		
FG52	2,080	Open area after bend	11.0	7.26	128		
FG53	2,150	Narrow channel above confluence with re-emergent flow from FG41	9.0	7.19	132		
FG55	2,200	Below FG53/54 confluence	8.0	7.32	184		
FG45	2,388	Open area 100 meters upstream from triple power pole; upstream from dirty inflow	7.5	7.28	170		
TS06	2,536	Site T6 (State FG7 site) downstream from inflow of acid drainage	7.5	7.38	214	376.6	297.0
FG46	2,540	South branch inflow to Dead Elk Pond (State site FG8)	7.0	7.28	122		
FG42	2,600	Culvert at the end of Dead Elk Pond; farthest downstream point	8.0	7.31	139		

**Appendix 3 Site description and physical properties of water from synoptic sampling sites, French Gulch, Colorado, July 26, 1996—Continued**

Site	Distance	Description of site	Temp	pH	Cond	Q	Qmeter
<b>Inflow sites</b>							
FG06	333	LB water exits from rocks all the way over to the dredge pile	8.5	8.5	97		
FG09b	694	LB water exits from rocks	6.0	8.5	95		
FG09c	695	RB water exits from rocks	7.0	7.50	117		
FG10	745	LB water exits from rocks; downstream end of culvert at Country Boy mine	6.5	8.50	102		
FG12	769	RB another inflow; large flow from rocks	6.5	8.05	100		
FG13	784	RB third inflow RB 20 feet downstream again	8.0	8.04	101		
FG16	812	Inflow LB along cascade section		7.62	266		
FG16b	813	RB inflow – mine water	8.0	7.77	135		
FG16c	814	RB inflow – mine water	8.0	7.78	144		
FG19	840	LB inflow	6.0	7.53	306		
FG15	840	RB pool with "yellow boy" precipitate; downstream from FG-16	8.0	7.27	292		
FG22	857	LB	10.0	8.09	444		
FG27	1,073	LB inflow near double tower; about 10 meters left of stream	17.5	7.87	366		
FG32	1,266	RB just around bend, about 3 meters	6.5	7.72	135		
FG36b	1,605	Inflow added 7/24/96, never makes it to the stream - parallels stream	6.5	7.60	144		
FG38	1,701	Inflow RB spring at base of dredge pile; water coming in all along base of	5.0	6.63	860		
FG51	1,980	Drainage from spring FG-6; re-enters split off branch after pond	7.5	7.34	137		
FG54	2,150	Re-emergent water from FG41 area	7.5	7.19	206		
FG44	2,400	Mine drainage, dirty inflow RB; - sample near road instead of by stream	7.0	7.01	412		
FG56	2,422	FG44 and water from the base of rubble pile where it joins stream	8.0	7.97	280		
<b>Bullhide Fault surface drainage</b>							
FG39b	1,826	RB inflow below pond; orange suggests it differs from water out of pond	9.0	7.33	262		
FG40	1,869	North branch beyond pond; water leaving channel at this point	9.0	7.38	251		
FG41	1,920	Point where all the water goes under the rocks (drain from pond only)	9.0	7.30	244		

**Appendix 4. Concentration of major ions in water from synoptic sampling sites along French Gulch, Colorado, July 26, 1996**

[Dist, distance downstream from injection site, in meters; Site, field sample and flag identifier; concentration in milligrams per liter]

Dist	Site	Calcium	Magnesium	Sodium	Potassium	Chloride	Sulfate	Bicarbonate
<b>Stream samples</b>								
0	FG00	17.8	1.43	1.3		.1	10.6	39.4
84	FG03	17.9	1.42	4.0		3.4	10.6	39.9
234	FG05	18.6	1.47	4.2		3.4	10.6	40.4
516	TS02	17.5	1.40	...		3.3	10.6	40.2
631	FG09	17.7	1.42	3.6		3.3	10.6	39.4
744	FG09d	22.1	1.93	1.5		.4	15.3	47.9
799	TS03	22.0	1.92	2.0		1.0	14.3	45.4
825	FG17b	21.1	1.95	2.0		1.1	15.1	44.8
881	FG18	23.2	2.49	2.0	2.0	1.1	20.6	47.2
981	FG25	23.0	2.62	2.0		1.2	21.5	45.1
1,087	FG28	23.2	2.62	2.0		1.3	21.9	45.7
1,161	TS04	22.6	2.54	2.0		1.2	22.5	45.3
1,242	FG31	23.2	2.60	2.0		1.2	23.6	45.6
1,356	FG33	22.8	2.55	2.0		1.2	23.5	45.1
1,515	FG35	23.2	2.59	2.0		1.2	21.5	44.8
1,651	TS05	22.7	2.54	2.0		1.2	23.1	46.2
1,751	FG39	28.0	4.01	2.0		1.1	46.7	43.5
1,880	FG50	21.8	2.47	1.9		1.2	21.6	45.1
2,080	FG52	23.0	2.60	2.0		1.2	21.6	45.8
2,150	FG53	22.7	2.60	2.0		1.1	24.4	45.0
2,200	FG55	28.2	4.08	2.1		1.2	44.6	42.0
2,388	FG45	26.5	3.90	2.0		1.1	46.3	42.5
2,536	TS06	30.1	5.00	2.1		1.1	62.0	40.4
2,540	FG46	21.3	2.63	1.6	1.0	.8	25.7	39.1
2,600	FG42	26.8	4.19	1.9		1.1	53.4	39.9
<b>Inflow samples</b>								
333	FG06	18.3	1.44	3.4		3.1	10.8	39.1
694	FG09b	19.4	1.71	1.3		.2	12.8	42.9
695	FG09c	22.8	1.98	1.8		.9	16.2	48.5
745	FG10	20.0	1.74	1.6		.7	12.7	44.8
769	FG12	18.4	1.50	2.9		2.6	11.3	39.8
784	FG13	20.0	1.65	2.7		2.4	12.6	40.9
812	FG16	39.4	7.75	1.6		.3	76.6	52.3
813	FG16b	23.1	2.39	2.5		2.2	23.2	41.6
814	FG16c	23.2	2.72	2.7		2.4	26.2	40.3
840	FG19	43.2	8.95	1.6		.4	86.7	56.9
840	FG15	33.1	8.07	2.5		2.1	95.6	36.0

**Appendix 4. Concentration of major ions in water from synoptic sampling sites along French Gulch, Colorado, July 26, 1996—Continued**

Dist	Site	Calcium	Magnesium	Sodium	Potassium	Chloride	Sulfate	Bicarbonate
<b>Inflow samples—Continued</b>								
857	FG22	72.6	14.2	2.0	2.0	.4	104	124
1,073	FG27	63.8	6.07	3.4		.3	59.9	119
1,266	FG32	23.3	2.57	2.0		1.1	23.2	43.4
1,605	FG36b	24.7	2.94	1.7		.9	29.3	43.1
1,701	FG38	1.2	0	3.7	2.0	1.5	453	26.3
1,980	FG51	22.7	2.53	1.4		.9	23.2	41.1
2,150	FG54	30.0	4.68	2.0		1.1	60.7	39.9
2,400	FG44	52.8	12.2	2.7		1.4	176	29.6
2,422	FG56	39.3	7.72	2.5	1.0	1.2	97.2	37.5
<b>Bullhide Fault surface flow</b>								
1,826	FG39b	36.1	6.26	2.2		1.2	76.7	39.6
1,869	FG40	35.5	5.97	2.2		1.2	76.4	40.4
1,920	FG41	34.8	5.72	2.2	1.0	1.2	67.3	41.3



**Appendix 5. Concentration of metals in water from synoptic sampling sites along French Gulch, Colorado, July 26, 1996**

[Dist, distance downstream from injection site, in meters; Site, field sample identifier; concentration in micrograms per liter; -d, dissolved concentration; -, total recoverable concentration; Al, aluminum; Cd, cadmium; Cu, copper; Fe, iron; Mn, manganese; Pb, lead; Zn, zinc. Blank entries indicate concentrations below detection limits]

Dist	Site	Al-d	Al-t	Cd-d	Cd-t	Cu-d	Cu-t	Fe-d	Fe-t	Mn-d	Mn-t	Pd-d	Pd-t	Zn-d	Zn-t
Stream samples															
0	FG00		55.0						74.9	3.0	6.0		1.0	8.5	10.2
84	FG03								19.9	2.0	4.0		1.0	7.3	8.1
234	FG05							8.0	24.3	2.0	4.0			9.3	10.6
516	TS02								24.9	1.0	2.0		1.0	15.5	14.8
631	FG09								23.0	2.0	4.0		1.0	14.1	17.4
744	FG09d								6.4					10.2	11.2
799	TS03		62.0		1.0				69.9		4.0		2.0	47.8	50.5
825	FG17b		63.0	2.0	2.0		1.0	6.0	82.0	60.0	67.0		2.0	368	372
881	FG18		72.0	4.0	4.0			6.0	64.9	111	119		2.0	699	704
981	FG25		69.0	8.0	8.0			13.0	88.2	302	320			1,570	1,570
1,087	FG28		81.0	8.0	8.0		2.0	13.0	80.7	305	314			1,590	1,550
1,161	TS04		57.0	8.0	8.0			9.0	93.6	289	313			1,520	1,560
1,242	FG31		68.0	8.0	8.0			16.0	82.2	292	307		1.0	1,540	1,570
1,356	FG33		55.0	8.0	8.0		1.0	11.0	79.9	281	308			1,480	1,570
1,515	FG35		48.0	7.0	8.0			11.0	64.5	285	299			1,500	1,520
1,651	TS05			7.0	8.0			23.0	58.2	271	291			1,430	1,490
1,751	FG39	76.0	55.0	11.0	12.0	2.0	1.0	34.0	77.9	809	851		1.0	3,180	3,240
1,880	FG50		66.0	7.0	8.0	1.0	2.0	11.0	40.1	243	266		1.0	1,340	1,420
2,080	FG52		43.0	7.0	8.0		1.0	6.0	44.7	249	270		1.0	1,360	1,430
2,150	FG53		77.0	7.0	8.0			19.0	51.8	237	254		1.0	1,350	1,410
2,200	FG55		40.0	10.0	12.0			36.0	114	631	667	1.0	3.0	2,980	3,060
2,388	FG45	40.0		9.0	11.0			26.0	118	603	617	1.0	3.0	2,880	3,020
2,536	TS06	43.0		12.0	12.0	2.0	2.0	53.0	204	1,090	1,120		5.0	4,510	4,740
2,540	FG46	44.0		3.0	4.0				61.2	14.0	18.0		2.0	647	702
Inflow samples															
333	FG06								26.8		2.0		1.0	13.6	14.8
530	MW9			1.0	9.0										
694	FG09b								8.2					8.1	11.2
695	FG09c								39.8		2.0		1.0	16.9	17.0

Appendix 5. Concentration of metals in water from synoptic sampling sites along French Gulch, Colorado, July 26, 1996—Continued

Dist	Site	Al-d	Al-t	Cd-d	Cd-t	Cu-d	Cu-t	Fe-d	Fe-t	Mn-d	Mn-t	Pd-d	Pd-t	Zn-d	Zn-t
Inflow samples—Continued															
745	FG10		119		1.0				136		7.0		3.0	37.2	58.5
769	FG12			0.0	1.0	1.0		7.0	48.4		4.0		1.0	76.2	79.8
784	FG13		127	1.0	1.0				183		15.0		5.0	122	135
812	FG16			20.0	18.0				38.8	5.0	8.0			5,410	5,080
813	FG16b			2.0	2.0			61.0	115	297	311			641	637
814	FG16c			10.0	11.0	1.0	3.0	60.0	122	466	458			2,140	2,000
840	FG19			21.0	20.0			10.0	15.8	3.0	4.0		1.0	5,620	5,550
840	FG15		278	76.0	76.0	4.0	8.0	55.0	637	3,480	3,450		3.0	16,300	15,800
857	FG22			3.0	3.0					92.0	97.0			2,020	2,000
1,073	FG27							31.0	277	134	183			7.3	10.8
1,266	FG32		210	5.0	6.0				183	12.0	37.0		2.0	1,040	1,100
1,605	FG36b			4.0	5.0			9.0	13.9	13.0	14.0			737	750
1,701	FG38	58.0	58.0	121.0	130.0	13.0	14.0	182	201	15,300	17,100	24.0	21.0	43,900	47,200
1,980	FG51			3.0	4.0			12.0	20.7	12.0	14.0			470	487
2,150	FG54		131	12.0	13.0	1.0	1.0	48.0	154	832	922	2.0	5.0	3,740	3,990
2,400	FG44			25.0	31.0			178	1,030	5,010	5,400	4.0	17.0	17,100	18,000
2,422	FG56			17.0	20.0			159	420	2,360	2,320	1.0	8.0	8,640	8,640
Bullhide Fault surface flow															
1,826	FG39b			16.0	17.0		2.0	428	929	1,510	1,600		14.0	5,930	6,150
1,869	FG40			14.0	13.0		1.0	196	427	1,470	1,520		6.0	5,400	5,400
1,920	FG41		54.0	13.0	14.0			122	374	1,310	1,360	1.0	6.0	4,910	4,960

# **FRENCH GULCH BACKGROUND WATER CHEMISTRY DATA: July 22–23, 1996**

Sampling Station	Sample Collection Date & Time	Field Measurements				Alk mg/l	TSS mg/l	F mg/l	Cl mg/l	SO <sub>4</sub> mg/l	Br mg/l
		Flow cfs	Temp °C	Cond µmhos/cm	pH su						
FG-1	7/22/96 @1850	9.41	12.7	67.5	7.87	32.9	<4	<0.2	1.21	12.8	<0.5
FG-3	7/22/96 @1750	9.71	11.8	77.3	8.04	38.3	<4	<0.2	1.31	11.7	<0.5
FG-5	7/22/96 @1655	3.29	12.5	82.3	8.01	38.6	<4	<0.2	1.29	13.2	<0.5
CBMA-1	7/23/96 @1435	0.316	5.5	315	7.47	124	<4	0.29	1.56	100	<0.5
FG-6C	7/22/96 @1620	* 0.067	11.5	2770	6.32	14.0	77	<0.2	3.87	2690	1.98
FG-6B	7/22/96 @1550	0.226	14.3	2090	6.47	5.40	48	<0.2	2.72	1660	<0.5
FG-6D	7/22/96 @1605	* 0.006	6.9	425	6.62	-----	-----	-----	-----	-----	-----
FG-6A	7/22/96 @1525	0.207	17.3	1722	6.24	<5	31	<0.2	2.51	1160	<0.5
FG-7	7/22/96 @1445	11.6	10.7	166	7.67	39.6	<4	<0.2	1.43	59.7	<0.5
FG-8	7/22/96 @1405	3.73	9.3	105	7.74	38.3	<4	<0.2	1.40	25.7	<0.5
FG-9A	7/22/96 @1330	14.9	10.6	147	7.87	39.4	<4	0.20	1.49	47.9	<0.5
1121	7/23/96 @1525	-----	5.1	653	6.70	24.0	<4	0.33	2.19	466	<0.5
MGB-1	7/23/96 @1353	* 0.017	10.6	146	7.66	33.5	<4	0.20	1.67	47.7	<0.5
RLCVT-1	7/23/96 @1345	* 1.75	7.0	145	7.50	33.9	<4	<0.2	1.61	50.7	<0.5
FG-9	7/22/96 @1230	13.9	9.3	142	7.75	34.5	<4	<0.2	1.58	50.2	<0.5
FG-9 Day #2	7/23/96 @1255	12.7	8.6	143	7.52	-----	-----	-----	-----	-----	-----
BR-1	7/23/96 @1215	65.4	13.1	70.2	8.12	37.9	<4	0.21	1.82	6.9	<0.5
BR-2	7/23/96 @1140	78.8	12.0	83.7	8.24	36.8	<4	0.21	1.79	13.5	<0.5
BR-3	7/23/96 @1000	121	10.4	87.2	8.02	39.9	<4	0.20	2.56	12.3	<0.5
SR-1	7/23/96 @1100	28.5	9.7	83.6	7.93	39.7	<4	<0.2	1.65	12.7	<0.5
SR-1 Replicate	7/23/96 @1100	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
BR-5	7/23/96 @0915	175	11.1	85.2	8.01	41.6	<4	0.20	2.56	13.2	<0.5
BR-5 Replicate	7/23/96 @0915	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

\* Flow for these stations was estimated onsite.

# FRENCH GULCH BACKGROUND WATER CHEMISTRY DATA: July 22-23, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk mg/l	Hardness mg/l	Cd-t µg/l	Cd-d µg/l	Cr-t µg/l	Cr-d µg/l	Cu-t µg/l	Cu-d µg/l
FG-1	7/22/96 @1850	7.87	32.9	40.6	<0.5	<0.5	<4	<4	<0.8	1.5
FG-3	7/22/96 @1750	8.04	38.3	46.4	<0.5	<0.5	<4	<4	<0.8	<0.8
FG-5	7/22/96 @1655	8.01	38.6	46.1	<0.5	<0.5	<4	<4	<0.8	<0.8
CBMA-1	7/23/96 @1435	7.47	124	224	2.9	2.0	<4	<4	<0.8	<0.8
FG-6C	7/22/96 @1620	6.32	14.0	1720	284	281	<4	<4	12.8	8.0
FG-6B	7/22/96 @1550	6.47	5.40	1230	114	114	<4	<4	10.9	4.2
FG-6D	7/22/96 @1605	6.62	-----	-----	10.4	-----	<4	-----	1.3	-----
FG-6A	7/22/96 @1525	6.24	<5	908	72.5	71.0	<4	<4	5.2	2.3
FG-7	7/22/96 @1445	7.67	39.6	96.2	10.6	11.9	<4	<4	1.0	<0.8
FG-8	7/22/96 @1405	7.74	38.3	63.6	3.2	3.0	<4	<4	1.1	<0.8
FG-9A	7/22/96 @1330	7.87	39.4	84.7	7.6	8.9	<4	<4	1.8	<0.8
1121	7/23/96 @1525	6.70	24.0	446	136	136	<4	<4	16.7	15.3
MGB-1	7/23/96 @1353	7.66	33.5	81.5	6.1	5.4	<4	<4	0.8	<0.8
RLCVT-1	7/23/96 @1345	7.50	33.9	86.1	6.2	5.5	<4	<4	<0.8	<0.8
FG-9	7/22/96 @1230	7.75	34.5	83.7	4.5	5.6	<4	6.2	<0.8	<0.8
FG-9 Day #2	7/23/96 @1255	7.52	-----	-----	7.6	-----	4.4	-----	<0.8	-----
BR-1	7/23/96 @1215	8.12	37.9	41.7	<0.5	<0.5	<4	<4	<0.8	<0.8
BR-2	7/23/96 @1140	8.24	36.8	48.8	1.3	1.1	<4	<4	<0.8	<0.8
BR-3	7/23/96 @1000	8.02	39.9	50.1	0.9	0.5	<4	<4	<0.8	<0.8
SR-1	7/23/96 @1100	7.93	39.7	49.9	<0.5	<0.5	<4	<4	<0.8	<0.8
SR-1 Replicate	7/23/96 @1100	-----	-----	-----	<0.5	-----	<4	-----	<0.8	-----
BR-5	7/23/96 @0915	8.01	41.6	52.3	1.0	<0.5	<4	<4	<0.8	<0.8
BR-5 Replicate	7/23/96 @0915	-----	-----	51.5	-----	0.7	-----	<4	-----	<0.8

NOTE: "-t" = Total Recoverable    "-d" = Dissolved

# FRENCH GULCH BACKGROUND WATER CHEMISTRY DATA: July 22-23, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk mg/l	Hardness mg/l	Ag-t µg/l	Ag-d µg/l	Zn-t µg/l	Zn-d µg/l	Al-t µg/l	Al-d µg/l
FG-1	7/22/96 @1850	7.87	32.9	40.6	<0.2	<0.2	7.0	19.6	<40	<40
FG-3	7/22/96 @1750	8.04	38.3	46.4	<0.2	<0.2	8.4	15.6	43	<40
FG-5	7/22/96 @1655	8.01	38.6	46.1	<0.2	<0.2	14.6	32.6	<40	<40
CBMA-1	7/23/96 @1435	7.47	124	224	<0.2	<0.2	3000.4	2796.0	<40	<40
FG-6C	7/22/96 @1620	6.32	14.0	1720	<0.2	<0.2	255690	244820	306	118
FG-6B	7/22/96 @1550	6.47	5.40	1230	<0.2	<0.2	154020	149000	317	<40
FG-6D	7/22/96 @1605	6.62	-----	-----	<0.2	-----	18772	-----	<40	-----
FG-6A	7/22/96 @1525	6.24	<5	908	<0.2	<0.2	107700	102530	255	46
FG-7	7/22/96 @1445	7.67	39.6	96.2	<0.2	<0.2	4618.3	4483.6	<40	156
FG-8	7/22/96 @1405	7.74	38.3	63.6	<0.2	<0.2	681.3	658.7	55	55
FG-9A	7/22/96 @1330	7.87	39.4	84.7	<0.2	<0.2	3381.1	3304.1	<40	<40
1121	7/23/96 @1525	6.70	24.0	446	<0.2	<0.2	50549	50447	59	81
MGB-1	7/23/96 @1353	7.66	33.5	81.5	<0.2	<0.2	1616.8	1536.6	194	<40
RLCVT-1	7/23/96 @1345	7.50	33.9	86.1	<0.2	<0.2	2083.4	2012.2	<40	<40
FG-9	7/22/96 @1230	7.75	34.5	83.7	<0.2	<0.2	2270.1	2216.4	<40	80
FG-9 Day #2	7/23/96 @1255	7.52	-----	-----	<0.2	-----	2293.6	-----	<40	-----
BR-1	7/23/96 @1215	8.12	37.9	41.7	<0.2	<0.2	8.8	8.8	76	<40
BR-2	7/23/96 @1140	8.24	36.8	48.8	<0.2	<0.2	415.1	376.7	63	<40
BR-3	7/23/96 @1000	8.02	39.9	50.1	<0.2	<0.2	147.7	131.2	344	<40
SR-1	7/23/96 @1100	7.93	39.7	49.9	<0.2	<0.2	10.0	7.2	72	<40
SR-1 Replicate	7/23/96 @1100	-----	-----	-----	<0.2	-----	8.2	-----	55	-----
BR-5	7/23/96 @0915	8.01	41.6	52.3	<0.2	<0.2	113.6	98.7	121	<40
BR-5 Replicate	7/23/96 @0915	-----	-----	51.5	-----	<0.2	-----	99.0	-----	<40

NOTE: "-t" = Total Recoverable    "-d" = Dissolved

# FRENCH GULCH BACKGROUND WATER CHEMISTRY DATA: July 22–23, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk mg/l	Hardness mg/l	Ni-t µg/l	Ni-d µg/l	As-t µg/l	As-d µg/l
FG-1	7/22/96 @1850	7.87	32.9	40.6	<10	<10	<1	<1
FG-3	7/22/96 @1750	8.04	38.3	46.4	<10	<10	<1	1.20
FG-5	7/22/96 @1655	8.01	38.6	46.1	<10	<10	1.20	<1
CBMA-1	7/23/96 @1435	7.47	124	224	<10	<10	<1	1.30
FG-6C	7/22/96 @1620	6.32	14.0	1720	283.4	281.7	4.70	4.20
FG-6B	7/22/96 @1550	6.47	5.40	1230	161.6	170.2	<1	<1
FG-6D	7/22/96 @1605	6.62	-----	-----	17.8	-----	<1	-----
FG-6A	7/22/96 @1525	6.24	<5	908	112.9	115.1	3.20	<1
FG-7	7/22/96 @1445	7.67	39.6	96.2	<10	<10	<1	<1
FG-8	7/22/96 @1405	7.74	38.3	63.6	<10	<10	<1	1.00
FG-9A	7/22/96 @1330	7.87	39.4	84.7	<10	<10	<1	<1
1121	7/23/96 @1525	6.70	24.0	446	43.0	57.5	<1	<1
MGB-1	7/23/96 @1353	7.66	33.5	81.5	<10	<10	<1	1.00
RLCVT-1	7/23/96 @1345	7.50	33.9	86.1	<10	<10	<1	<1
FG-9	7/22/96 @1230	7.75	34.5	83.7	<10	<10	<1	<1
FG-9 Day #2	7/23/96 @1255	7.52	-----	-----	<10	-----	<1	-----
BR-1	7/23/96 @1215	8.12	37.9	41.7	<10	<10	<1	<1
BR-2	7/23/96 @1140	8.24	36.8	48.8	<10	<10	<1	1.10
BR-3	7/23/96 @1000	8.02	39.9	50.1	<10	<10	<1	<1
SR-1	7/23/96 @1100	7.93	39.7	49.9	<10	<10	<1	<1
SR-1 Replicate	7/23/96 @1100	-----	-----	-----	<10	-----	<1	-----
BR-5	7/23/96 @0915	8.01	41.6	52.3	<10	<10	<1	<1
BR-5 Replicate	7/23/96 @0915	-----	-----	51.5	-----	<10	-----	<1

NOTE: "-t" = Total Recoverable    "-d" = Dissolved

# FRENCH GULCH BACKGROUND WATER CHEMISTRY DATA: July 22-23, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk mg/l	Hardness mg/l	Fe-t µg/l	Fe-d µg/l	Pb-t µg/l	Pb-d µg/l	Mn-t µg/l	Mn-d µg/l
FG-1	7/22/96 @1850	7.87	32.9	40.6	40.7	14.0	<0.8	<0.8	4.8	6.0
FG-3	7/22/96 @1750	8.04	38.3	46.4	35.0	<5	<0.8	<0.8	5.0	3.6
FG-5	7/22/96 @1655	8.01	38.6	46.1	26.3	18.1	<0.8	<0.8	2.8	6.8
CBMA-1	7/23/96 @1435	7.47	124	224	1095.7	526.9	1.9	<0.8	892.3	862.4
FG-6C	7/22/96 @1620	6.32	14.0	1720	355400	339140	397.47	59.0	98609.0	100857
FG-6B	7/22/96 @1550	6.47	5.40	1230	174250	163200	230.39	12.8	60213.8	60635.5
FG-6D	7/22/96 @1605	6.62	-----	-----	8250.7	-----	<0.8	-----	6806.0	-----
FG-6A	7/22/96 @1525	6.24	<5	908	109870	95411	144.68	1.1	42337.3	41105.8
FG-7	7/22/96 @1445	7.67	39.6	96.2	283.7	96.8	6.5	0.9	1165.6	1119.1
FG-8	7/22/96 @1405	7.74	38.3	63.6	118.6	5.6	3.7	<0.8	19.7	15.8
FG-9A	7/22/96 @1330	7.87	39.4	84.7	153.4	28.6	4.2	<0.8	804.9	777.8
1121	7/23/96 @1525	6.70	24.0	446	417.1	117.1	45.76	23.7	17213.7	17746.9
MGB-1	7/23/96 @1353	7.66	33.5	81.5	297.3	<5	4.7	<0.8	8.5	1.4
RLCVT-1	7/23/96 @1345	7.50	33.9	86.1	46.5	<5	1.4	<0.8	11.7	7.2
FG-9	7/22/96 @1230	7.75	34.5	83.7	38.4	38.2	5.6	3.4	32.5	30.7
FG-9 Day #2	7/23/96 @1255	7.52	-----	-----	44.0	-----	5.5	-----	31.1	-----
BR-1	7/23/96 @1215	8.12	37.9	41.7	150.7	20.6	1.2	<0.8	18.7	6.1
BR-2	7/23/96 @1140	8.24	36.8	48.8	133.7	20.2	1.1	<0.8	20.9	9.7
BR-3	7/23/96 @1000	8.02	39.9	50.1	194.4	6.8	<0.8	<0.8	9.8	3.2
SR-1	7/23/96 @1100	7.93	39.7	49.9	72.6	6.3	<0.8	<0.8	7.6	4.4
SR-1 Replicate	7/23/96 @1100	-----	-----	-----	67.2	-----	<0.8	-----	7.4	-----
BR-5	7/23/96 @0915	8.01	41.6	52.3	116.3	<5	<0.8	<0.8	7.6	3.7
BR-5 Replicate	7/23/96 @0915	-----	-----	51.5	-----	<5	-----	<0.8	-----	3.4

NOTE: "-t" = Total Recoverable      "-d" = Dissolved

# FRENCH GULCH BACKGROUND WATER CHEMISTRY DATA: July 22-23, 1996

Sampling Station	Sample Collection Date & Time	Field Measurements				Alk mg/l	TSS mg/l	F mg/l	Cl mg/l	SO <sub>4</sub> mg/l	Br mg/l
		Flow cfs	Temp °C	Cond µmhos/cm	pH su						
<b>MW-1</b>	7/22/96 @1832	-----	8.9	2080	6.31	95.5	31	<0.2	2.01	1880	<0.5
<b>MW-1</b> Replicate	7/22/96 @1832	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
<b>MW-3</b>	7/22/96 @1855	-----	8.4	2510	5.90	83.2	60	<0.2	2.89	2580	2.13
<b>MSRW-3</b>	7/22/96 @1842	-----	9.2	2110	5.50	21.6	61	0.33	1.96	1960	1.89
<b>MW-9</b>	7/22/96 @1719	-----	7.3	362	7.32	100	<4	0.20	1.52	164	<0.5
<b>MW-16</b>	7/22/96 @1810	-----	9.3	2120	6.22	126	38	<0.2	1.96	1900	<0.5
<b>MW-20</b>	7/22/96 @1702	-----	6.3	259	7.17	94.7	61	0.25	1.64	85.2	<0.5
<b>ORO-1</b>	7/22/96 @1740	-----	9.0	1530	5.02	6.10	34	0.64	2.71	1290	<0.5



# FRENCH GULCH BACKGROUND WATER CHEMISTRY DATA: July 22-23, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk mg/l	Hardness mg/l	Ni-t µg/l	Ni-d µg/l	As-t µg/l	As-d µg/l
MW-1	7/22/96 @1832	6.31	95.5	1480	140.5	147.2	75.30	39.60
MW-1 Replicate	7/22/96 @1832	-----	-----	-----	141.2	-----	71.20	-----
MW-3	7/22/96 @1855	5.90	83.2	1540	202.6	195.8	31.40	21.70
MSRW-3	7/22/96 @1842	5.50	21.6	1470	112.9	118.5	10.80	4.70
MW-9	7/22/96 @1719	7.32	100	257	<10	<10	<1	<1
MW-16	7/22/96 @1810	6.22	126	1600	154.6	146.3	32.00	19.10
MW-20	7/22/96 @1702	7.17	94.7	135	<10	<10	3.80	<1
ORO-1	7/22/96 @1740	5.02	6.10	947	112.9	121.7	12.50	6.60

NOTE: "-t" = Total Recoverable      "-d" = Dissolved

# FRENCH GULCH BACKGROUND WATER CHEMISTRY DATA: July 22–23, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk mg/l	Hardness mg/l	Fe-t µg/l	Fe-d µg/l	Pb-t µg/l	Pb-d µg/l	Mn-t µg/l	Mn-d µg/l
<b>MW-1</b>	7/22/96 @1832	6.31	95.5	1480	166050	149110	1233.3	509.37	47035.4	45718.2
<b>MW-1</b> Replicate	7/22/96 @1832	-----	-----	-----	165320	-----	1232.1	-----	46986.0	-----
<b>MW-3</b>	7/22/96 @1855	5.90	83.2	1540	368280	325160	486.62	374.40	82210.2	76710.5
<b>MSRW-3</b>	7/22/96 @1842	5.50	21.6	1470	175680	163590	727.59	327.22	49179.8	50192.4
<b>MW-9</b>	7/22/96 @1719	7.32	100	257	247.4	10.4	5.3	<0.8	112.9	94.0
<b>MW-16</b>	7/22/96 @1810	6.22	126	1600	131800	119050	21.8	5.6	40329.5	38889.7
<b>MW-20</b>	7/22/96 @1702	7.17	94.7	135	4187.8	<5	17.8	<0.8	143.4	45.2
<b>ORO-1</b>	7/22/96 @1740	5.02	6.10	947	76830	68890	820.57	608.60	33919.2	32647.4

NOTE: "-t" = Total Recoverable      "-d" = Dissolved

# FRENCH GULCH BACKGROUND WATER CHEMISTRY DATA: July 22-23, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk mg/l	Hardness mg/l	Ag-t µg/l	Ag-d µg/l	Zn-t µg/l	Zn-d µg/l	Al-t µg/l	Al-d µg/l
MW-1	7/22/96 @1832	6.31	95.5	1480	<0.2	<0.2	191010	177090	560	180
MW-1 Replicate	7/22/96 @1832	-----	-----	-----	<0.2	-----	190660	-----	583	-----
MW-3	7/22/96 @1855	5.90	83.2	1540	<0.2	<0.2	230010	205120	1979	81
MSRW-3	7/22/96 @1842	5.50	21.6	1470	<0.2	<0.2	213800	205700	4063	1050
MW-9	7/22/96 @1719	7.32	100	257	<0.2	<0.2	100.9	92.5	60	<40
MW-16	7/22/96 @1810	6.22	126	1600	<0.2	<0.2	142660	131150	1128	<40
MW-20	7/22/96 @1702	7.17	94.7	135	<0.2	<0.2	142.8	38.7	3817	<40
ORO-1	7/22/96 @1740	5.02	6.10	947	1.10	<0.2	166840	155530	2577	1905

NOTE: "-t" = Total Recoverable      "-d" = Dissolved

# FRENCH GULCH BACKGROUND WATER CHEMISTRY DATA: July 22-23, 1996

Sampling Station	Sample Collection Date & Time	pH su	Alk mg/l	Hardness mg/l	Cd-t µg/l	Cd-d µg/l	Cr-t µg/l	Cr-d µg/l	Cu-t µg/l	Cu-d µg/l
MW-1	7/22/96 @1832	6.31	95.5	1480	187	156	<4	<4	186.6	20.2
MW-1 Replicate	7/22/96 @1832	-----	-----	-----	186	-----	<4	-----	190.0	-----
MW-3	7/22/96 @1855	5.90	83.2	1540	193	173	<4	<4	12.4	<0.8
MSRW-3	7/22/96 @1842	5.50	21.6	1470	597	589	<4	<4	207.1	183.7
MW-9	7/22/96 @1719	7.32	100	257	2.6	2.1	<4	<4	1.0	<0.8
MW-16	7/22/96 @1810	6.22	126	1600	91.3	78.4	<4	<4	1.9	<0.8
MW-20	7/22/96 @1702	7.17	94.7	135	2.5	1.9	<4	<4	10.9	1.4
ORO-1	7/22/96 @1740	5.02	6.10	947	343	323	<4	<4	178.9	69.6

NOTE: "-t" = Total Recoverable      "-d" = Dissolved

# FRENCH GULCH BACKGROUND WATER CHEMISTRY DATA: July 22-23, 1996

Sampling Station	Sample Collection Date & Time	TOC mg/l	NH <sub>3</sub> mg/l	NO <sub>2</sub> /NO <sub>3</sub> mg/l	PO <sub>4</sub> mg/l	Ca-d mg/l	Mg-d mg/l	Hardness mg/l	Na-d mg/l	K-d mg/l
MW-1	7/22/96 @1832	<1.5	0.19	0.05	0.05	385.6	126.4	1480	13.31	3.9
MW-1 Replicate	7/22/96 @1832	-----	-----	-----	-----	-----	-----	-----	-----	-----
MW-3	7/22/96 @1855	1.6	0.40	0.07	<0.02	380.4	144.5	1540	11.67	4.4
MSRW-3	7/22/96 @1842	1.6	0.17	0.05	0.02	376.0	130.1	1470	12.81	2.4
MW-9	7/22/96 @1719	<1.5	<0.05	<0.05	<0.02	90.80	7.39	257	2.79	1.1
MW-16	7/22/96 @1810	<1.5	0.16	<0.05	<0.02	432.8	126.3	1600	13.15	1.1
MW-20	7/22/96 @1702	<1.5	<0.05	<0.05	0.07	43.08	6.55	135	22.57	1.7
ORO-1	7/22/96 @1740	6.7	0.21	<0.05	0.03	242.5	82.98	947	9.34	4.5

NOTE: "-d" = Dissolved

# **FRENCH GULCH QA/QC DATA: July 23, 1996**

Sampling Station	Sample Collection Date & Time	Description	TOC mg/l	NH <sub>3</sub> mg/l	NO <sub>2</sub> /NO <sub>3</sub> mg/l	PO <sub>4</sub> mg/l	As-t µg/l	Cd-t µg/l	Cu-t µg/l	Pb-t µg/l	Ag-t µg/l	Al-t µg/l
QC-1	7/23/96 @1015	Container Blank	-----	-----	-----	-----	<1	<0.5	<0.8	<0.8	<0.2	<40
QC-2	7/23/96 @1015	Filter Blank	-----	-----	-----	-----	<1	<0.5	<0.8	<0.8	<0.2	<40
QC-3	7/23/96 @1015	HNO <sub>3</sub> Blank	-----	-----	-----	-----	<1	<0.5	<0.8	<0.8	<0.2	56
QC-4	7/23/96 @1015	H <sub>2</sub> SO <sub>4</sub> Blank	<1.5	<0.05	<0.05	<0.02	-----	-----	-----	-----	-----	-----

# **FRENCH GULCH QA/QC DATA: July 23, 1996**

Sampling Station	Sample Collection Date & Time	Description	Cr-t µg/l	Fe-t µg/l	Mn-t µg/l	Ni-t µg/l	Zn-t µg/l
QC-1	7/23/96 @1015	Container Blank	<4	5.5	<1	<10	4.3
QC-2	7/23/96 @1015	Filter Blank	<4	<5	<1	<10	<4
QC-3	7/23/96 @1015	HNO <sub>3</sub> Blank	<4	13.0	<1	<10	<4
QC-4	7/23/96 @1015	H <sub>2</sub> SO <sub>4</sub> Blank	-----	-----	-----	-----	-----

NOTE: "-t" = Total Recoverable



## Stable Isotopes and Metal Concentrations in French Gulch, CO

### Phase I Report

#### Introduction

This investigation is designed to resolve the roles of groundwater and surface waters in "toxic runoff" during the major Spring snowmelt in the French Gulch mining area, Colorado (see for example, Lawrence, 1987). The field investigation is being conducted in two phases.

1. Phase I provides baseline stable isotopic and metal concentration data (Cd, Fe, and Zn) for groundwaters and surface waters (springs, creek, snowpack) in French Gulch. If sufficient stable isotopic contrast exists between the snowpack and groundwaters/creek waters, a Phase II investigation would be carried out during the snowmelt event.
2. Phase II will provide information on the relative contributions of groundwater and snowmelt in French Creek at various stages of the Spring thaw. Groundwaters and surface waters would be sampled three times at one- to two-week intervals during the snowmelt event of the Spring of 1996. A final survey of groundwaters and surface waters may also be conducted after the watershed has returned to normal summer flow, at the discretion of the Colorado Division of Minerals and Geology.

#### Phase I Scope of Work

The baseline sampling was conducted by Radon Abatement Systems (RAS), Inc. on March 20, 1996. Ten water samples and one snow sample from a total of ten sites were collected prior to significant melting of the snowpack. The samples are described in Table 1.

**Table 1 - Sampled Sites for French Gulch Stable Isotope Investigation (Phase I)**

Sample #	Sample Type	Location	Comments
FG0001	Groundwater	MW #14	Clean, 11-10 fault, shale bedrock
FG0002	Groundwater	MW#9	Clean, lower Qal, upgradient from mine
FG0003	Groundwater	MW #16	Contaminated, shale bedrock at mine site
FG0004	Groundwater	MW#3	Contaminated, alluvial, below mill tailings
FG0005	Mine Water	#3 Mine	Relief Well
FG0006	French Creek		At 6C
FG0007	Spring water		Kenny Dog Spring, upgradient from mine
FG0008	Mine waste water	Soil Boring	At Roaster Fines
FG0009	French Creek		At Country Boy Mine, upstream from site
FG0010	Snow	Grab sample	At MW-9 location
FG0011	French Creek		Downstream from mine site



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### Notation

Geochemical results are given in mg/liter (ppm). Stable isotopic data are reported using delta (d) notation, expressing parts per thousand (‰ or per mil) differences between the isotope ratio of the sample and that of the standard, SMOW (Craig, 1961):

$$d^{18}\text{O} \text{ or } d\text{D} = ((R_s - R_{\text{SMOW}})/R_{\text{SMOW}}) \times 1000, \text{ where}$$

$$R = {}^{18}\text{O}/{}^{16}\text{O} \text{ or } \text{D}/\text{H},$$

s = sample, and

SMOW = Standard Mean Ocean Water.

### Results

The results of the stable isotopic and geochemical analyses conducted on Phase I samples are shown in Table 2.

**Table 2 -Stable Isotopic and Geochemical Data for Phase I Samples**

Sample #	Depth to Water (ft)	T (°C)	FEC (mS/cm)	pH	<u>Isotopic Composition</u>		<u>Concentration (mg/l)</u>		
					$d^{18}\text{O}$ (‰)	$d\text{D}$ (‰)	Cd	Fe	Zn
FG0001	24.0	8.6	1885	6.26	-17.7	-132	0.013	1.7	0.39
FG0002	20.8	5.0	260	7.06	-18.0	-131	<0.005	0.51	0.092
FG0003	13.6	10.1	2450	5.53	-18.9	-141	0.046	99.3	96.8
FG0004	17.0	9.4	2270	5.39	-18.2	-136	0.12	211	167
FG0005	13.4	8.1	2420	5.55	-18.8	-141	0.20	188	165
FG0006	na <sup>1</sup>	7.6	2480	5.35	-18.7	-141	0.14	201	159
FG0007	na	5.6	80	6.32	-21.0	-159	0.072	16.7	8.4
FG0008	na	11.2	25500	2.23	-17.4	-133	<0.5	26,900	4,530
FG0009	na	4.6	180	6.30	-18.0	-132	<0.005	2.2	0.4
FG0010	na	NA	NA	NA	-27.2	-206	NA <sup>2</sup>	NA	NA
FG0011	na	1.0	395	6.03	-18.1	-132	0.027	1.3	13.4

<sup>1</sup> na = not applicable, <sup>2</sup>NA = not analyzed





### Stable Isotopic Results

Groundwaters from French Gulch (Samples FG0001 through FG0005) exhibit restricted ranges of  $d^{18}O$  (-17.7 to -18.9 ‰) and  $dD$  (-131 to -142 ‰) values. The mean  $d^{18}O$  and  $dD$  values for these five groundwater samples are -18.3 ‰ and -136 ‰, respectively. Contaminated groundwaters from both shale and alluvial bedrock appear to be slightly depleted in  $^{18}O$  and deuterium compared to "clean" samples (based on only a few samples). Additional analyses would be necessary to verify this relationship.

Three samples from French Creek (FG0006, FG0009, and FG0011) exhibit similar  $d^{18}O$  values (-18.0 to -18.7 ‰), and the average value is identical to that for analyzed groundwater samples (-18.3 ‰).  $dD$  values for the three stream samples are also similar (-132 to -141 ‰) are close to the theoretical value of -136 ‰ for a meteoric water with a  $d^{18}O$  value of -18.3 ‰. The best estimate for the stable isotopic composition of French Creek (on March 20, 1996) is taken to be  $d^{18}O$  = -18.3 ‰ and  $dD$  = -136 ‰, equal to the average for analyzed groundwater samples.

Other surface water samples show a larger range of stable isotopic compositions.

- Sample FG0007 (Kenny Dog Spring, located above the mine site) has  $d^{18}O$  and  $dD$  values (-21.0 and -159 ‰) that are considerably lower than the other analyzed groundwaters, creek waters, and springs in French Gulch.
- Sample FG0008 (mine waste water from the Roaster Fines 3 area) has a slightly higher (less negative)  $d^{18}O$  value (-17.4 ‰) than other local groundwaters and creek samples, although the measured  $dD$  value (-133 ‰) is within the range exhibited by groundwater samples. This slight  $^{18}O$  enrichment may be due to minor evaporation (see discussion below).
- A grab sample of the snowpack near the MW-9 site has  $d^{18}O$  and  $dD$  values (-27.2 and -206 ‰) that are distinctly lower than all other Phase I samples.

### Geochemical and Geophysical Results

As expected, groundwater samples identified as being "clean" (FG0001 and FG0002) show low concentrations of Cd, Fe, and Zn, relatively low conductivities (<2,000 mS/cm), and nearly neutral pH values (between 6.0 and 7.0), whereas groundwaters identified as "contaminated" (FG0003 to FG0005) show considerably higher concentrations of these metals (Cd up to 0.2 mg/l, Fe up to 211 mg/l, Zn up to 167 mg/l), slightly higher conductivities (>2,000 mS/cm), and lower pH values (5.39 to 5.55).

The three samples from French Creek show a considerable range of metals concentrations. Sample FG0006 has metals concentrations (Cd = 0.14 mg/l, Fe = 201 mg/l, Zn = 159 mg/l), electrical conductivity, and pH similar to those of contaminated groundwaters in the area. The other two creek samples (FG0009 and FG0011) exhibit metals concentrations, electrical conductivities, and pH values similar to "clean" groundwaters in the area.

Other surface water samples show a very large range of metal concentrations.

- Sample FG0008, mine waste water from the Roaster Fines 3 area, has a very high concentration of Fe (26,900 mg/l) and Zn (4,530 mg/l). The Cd concentration of this sample (<0.5 mg/l) indicates that the sample is relatively less enriched in Cd than in Fe and Zn. Note also the very low pH value and high electrical conductivity of this sample.



- Sample FG0007 (Kenny Dog Spring, located above the mine site) has metal concentrations, pH, and electrical conductivity that are similar to those of local "clean" groundwaters (see further discussion below).
- Metals, pH, and conductivity analyses were not performed on the snow pack sample

### Discussion

The stable isotopic results for Phase I samples are shown on Figure 1. All samples fall on or near the global meteoric water line (MWL), indicating that the data are reasonably accurate and precise, and that none of the samples has suffered large amounts of evaporation. The position of the two spring samples slightly to the right of the global MWL, however, may indicate minor evaporation (Figures 1 and 2).

The isotopic similarity of local groundwaters and samples from French Creek indicates that the principal source of water in the Creek (at the time of sampling) is local groundwater.

Most importantly, the strong stable isotopic contrast between local groundwaters and French Creek samples ( $d^{18}O = -18.3 \pm 0.6 \text{ ‰}$ ) and the snowpack ( $d^{18}O = -27.2 \text{ ‰}$ ) provides considerable isotopic contrast for conducting the proposed Phase II investigation. Given the analytical uncertainty of  $\pm 0.1 \text{ ‰}$  for O-isotopic data on water samples, it will be possible to estimate snowmelt vs groundwater contributions to French Creek during the snowmelt event with an accuracy of approximately 2% (as illustrated below).

The distinctive stable isotopic composition of the Kenny Dog Spring sample may indicate that the spring is discharging water that (1) originates from a different local aquifer containing a relatively higher concentration of winter precipitation, or (2) contains a significant proportion of local snowmelt. Field observations at the time of sampling (W. Pedler, pers. comm. to B.M. Smith) lead us to favor the second alternative. If it is assumed that Kenny Dog Spring water had an original  $d^{18}O$  value of  $-18.3 \text{ ‰}$  (identical to the mean for French Creek and local groundwater samples), the snowmelt had a  $d^{18}O$  value of  $-27.2 \pm 0.1 \text{ ‰}$ , and the Kenny Dog Spring sample had a  $d^{18}O$  value of  $-21.0 \pm 0.1 \text{ ‰}$ , the calculated proportion of snowmelt in the sample is  $30 \pm 2\%$ . If the Kenny Dog Spring sample is diluted with 30% surficial snowmelt (with essentially no Cd, Fe, and Zn), then the metals concentrations should be shifted upward to correct for the dilution (i.e., divided by 0.70). This example illustrates the simple isotopic mass balancing capabilities for simple, two-component water mixtures.

Although there are strong correlations between metals contamination, low pH, and high electrical conductivity, there is no striking correlation between metal concentrations and stable isotope composition of French Gulch surface waters and groundwater samples. Metal concentrations in French Creek waters at the time of sampling were not controlled by mixing of discrete, isotopically and geochemically distinct waters. Under the hydrologic conditions in which Phase I investigation was conducted (late winter with no significant snowmelt), both the creek and the springs have isotopic compositions similar to local groundwater. Contaminated groundwaters, therefore, could be responsible for the measured metal contamination in one of the French Creek samples. Other contaminated surface waters such as the waste waters at the Roaster Fines, also have stable isotopic composition compatible with a local groundwater origin.



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### Recommendations

The stable isotopic and geochemical results of Phase I of this investigation are very similar to the anticipated results, based on our previous studies in Colorado and New Mexico:

Groundwaters and Creek waters are isotopically similar and exhibit limited ranges in stable isotopic compositions.

This preliminary investigation shows that considerable oxygen isotopic contrasts (8.9 ‰) exist between the snowpack and both the groundwaters and the water currently flowing in the French Creek. This isotopic contrast is large enough to allow meaningful mass balance calculations to be performed for the snowmelt event, with a precision of a few percent. The results of Phase I of this study indicate a very high probability of success for the proposed Phase II investigation at French Creek.

### References

Craig, H., Isotopic variations in meteoric waters, Science, V. 133, p. 1702-1703, 1961.

Lawrence, J., Use of contrasting D/H ratios of snows and groundwaters of Eastern New York State in watershed evaluation, Water Resources Research, v. 23, no. 3, p. 519-521, 1987.

## French Gulch Stable Isotope Baseline Results

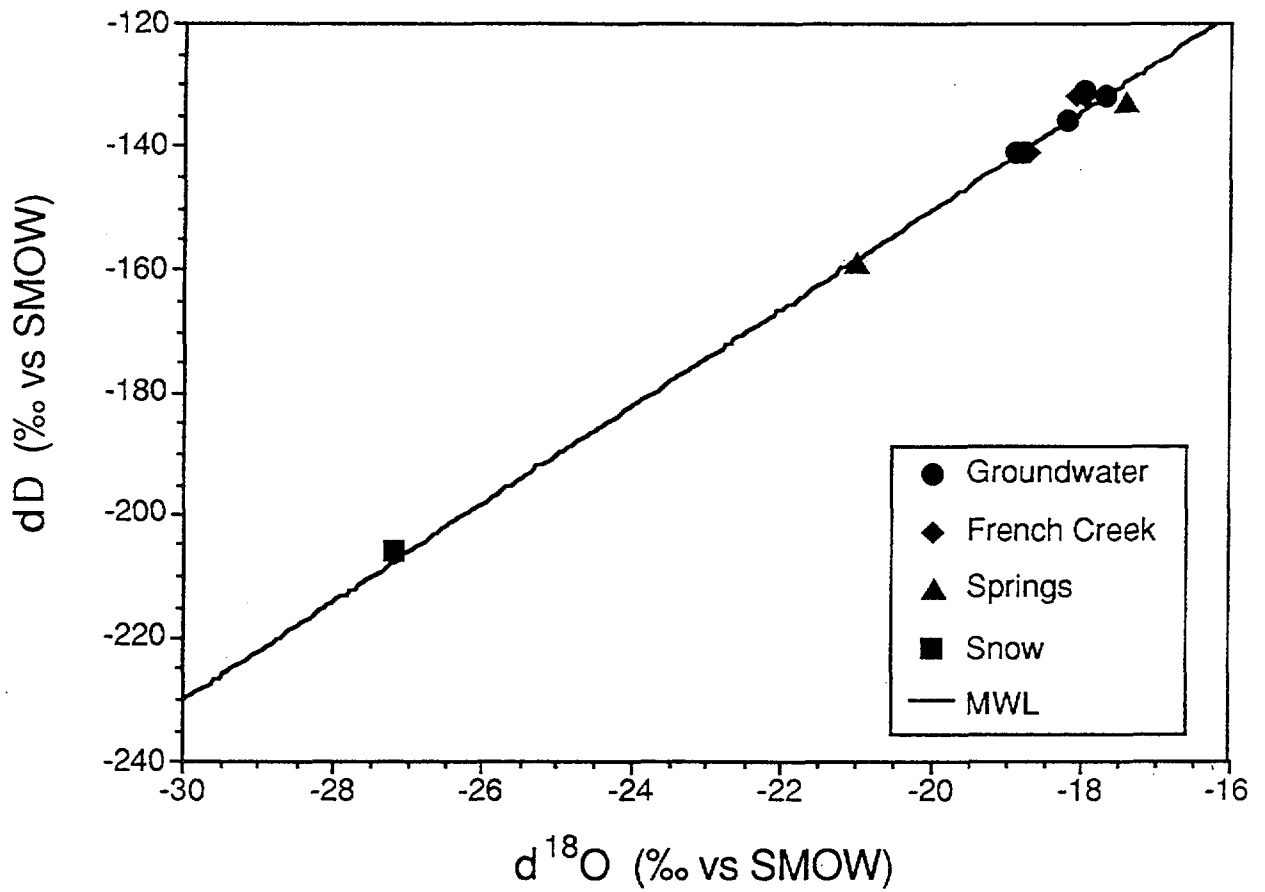


Figure 1.- Stable Isotopic composition of waters at French Gulch

### French Gulch Stable Isotope Baseline Results (Detail)

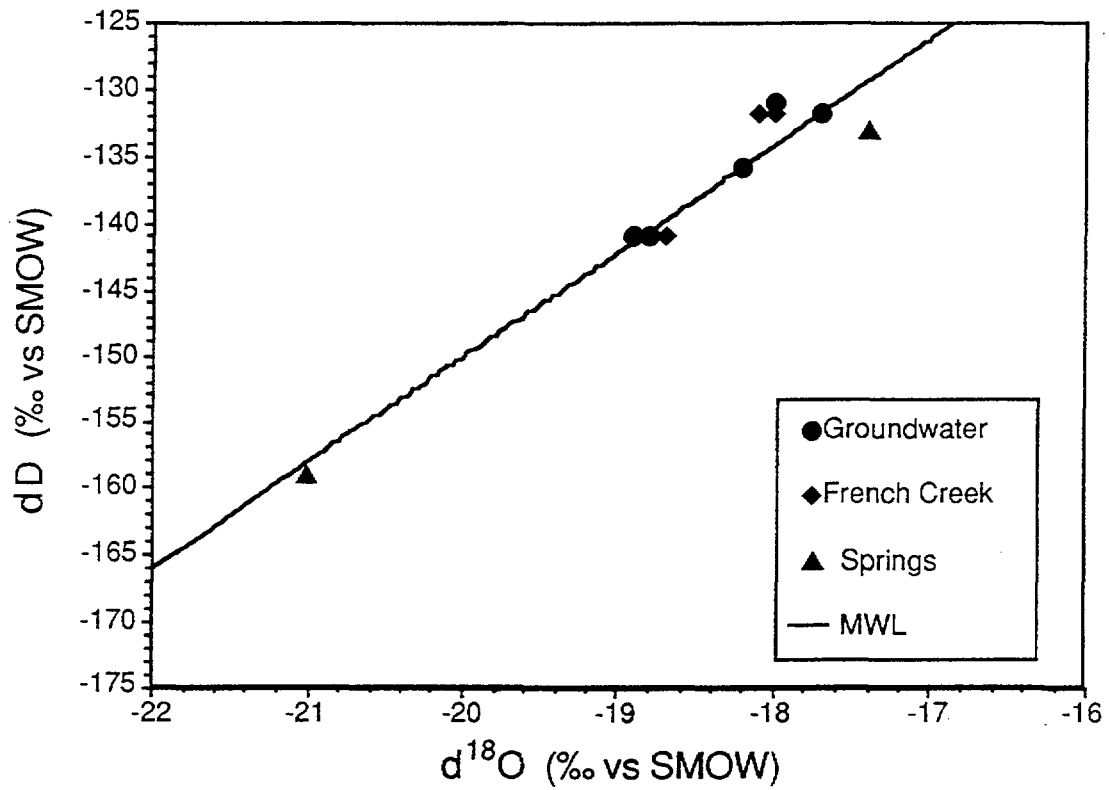
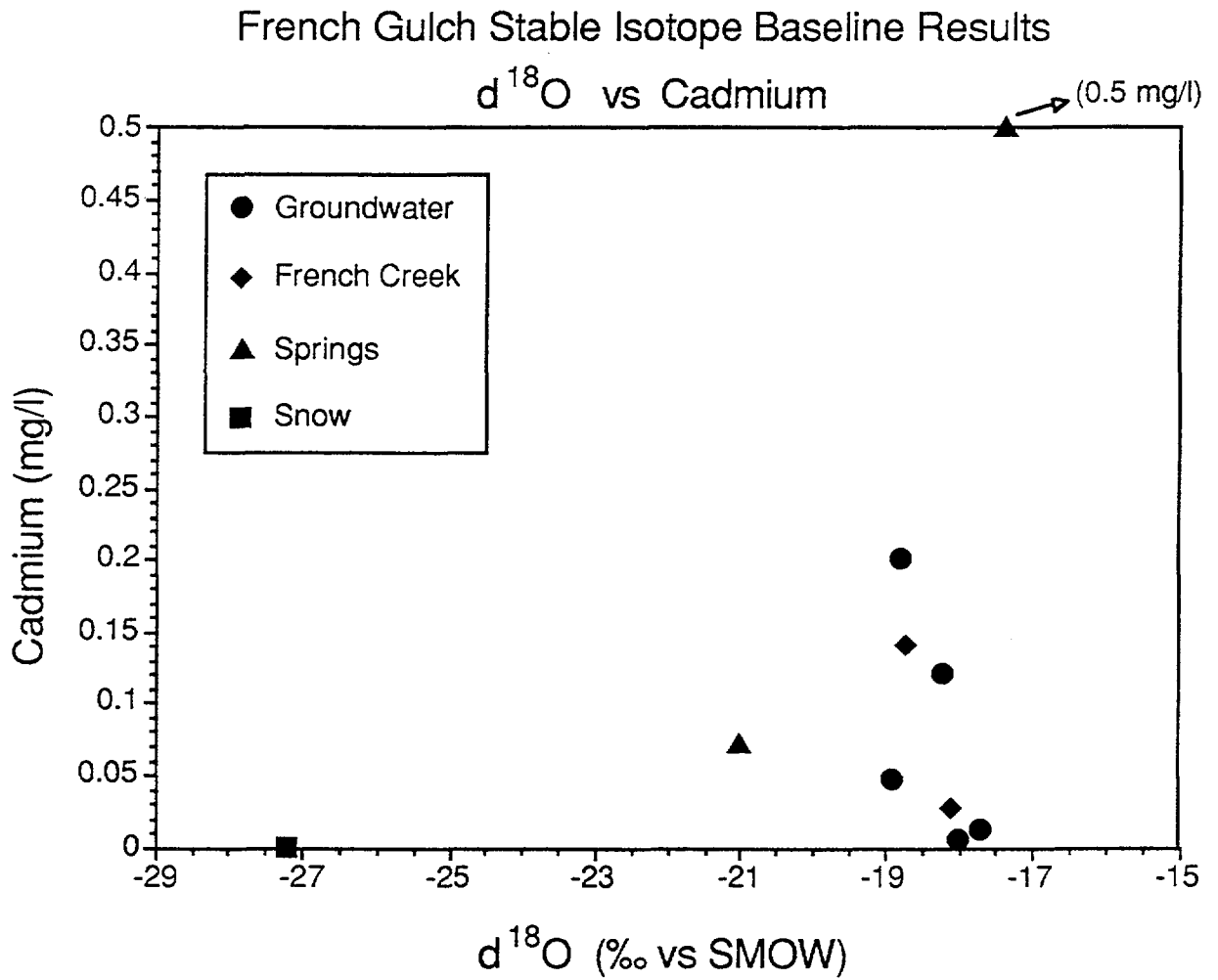


Figure 2.- Stable Isotopic composition of waters at French Gulch site (Detail)



**Figure 3.- Oxygen stable isotope composition vs cadmium concentrations in snow, surface waters and groundwaters at French Gulch**

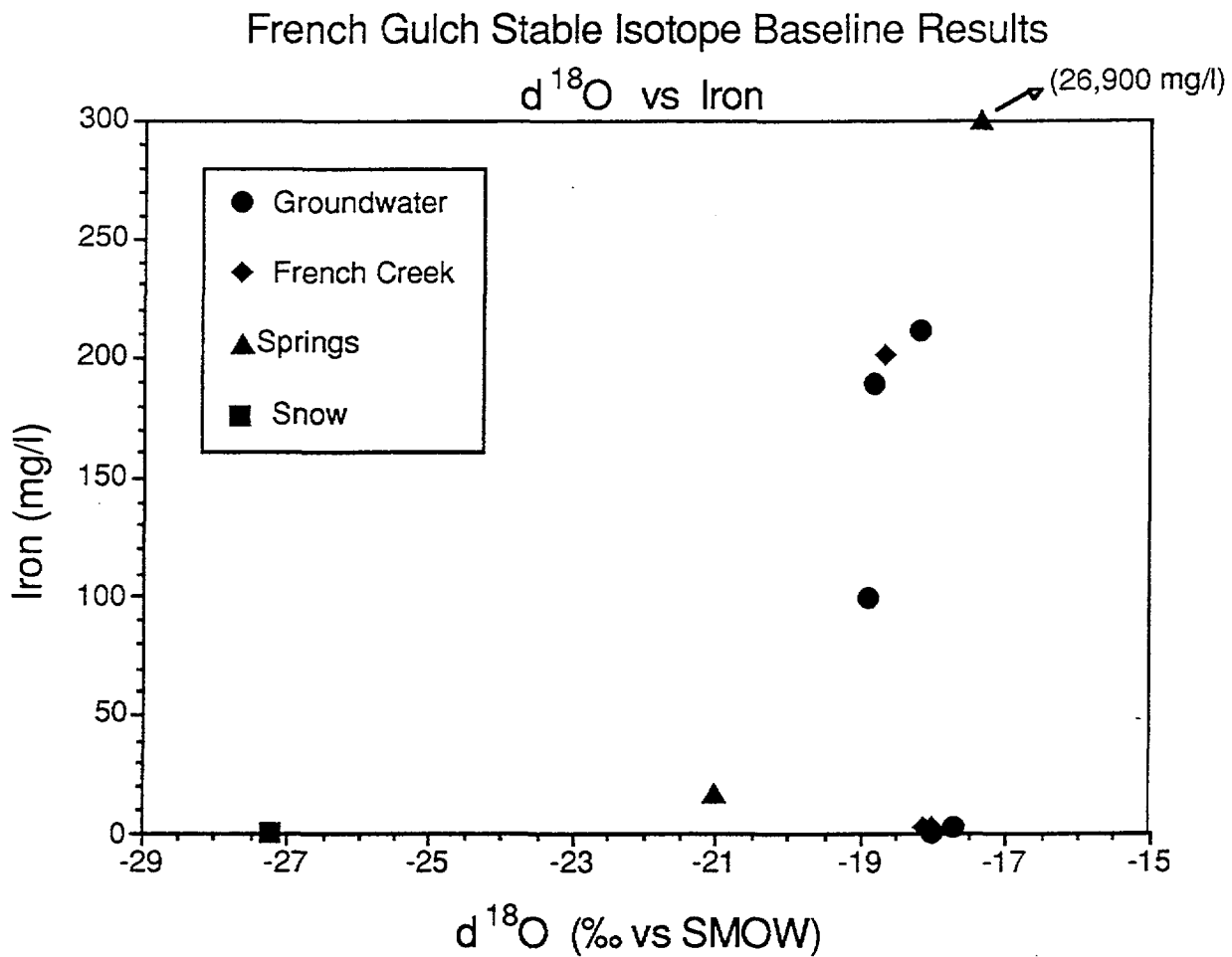


Figure 4.- Oxygen stable isotope composition vs iron concentrations in snow, surface waters and groundwaters at French Gulch

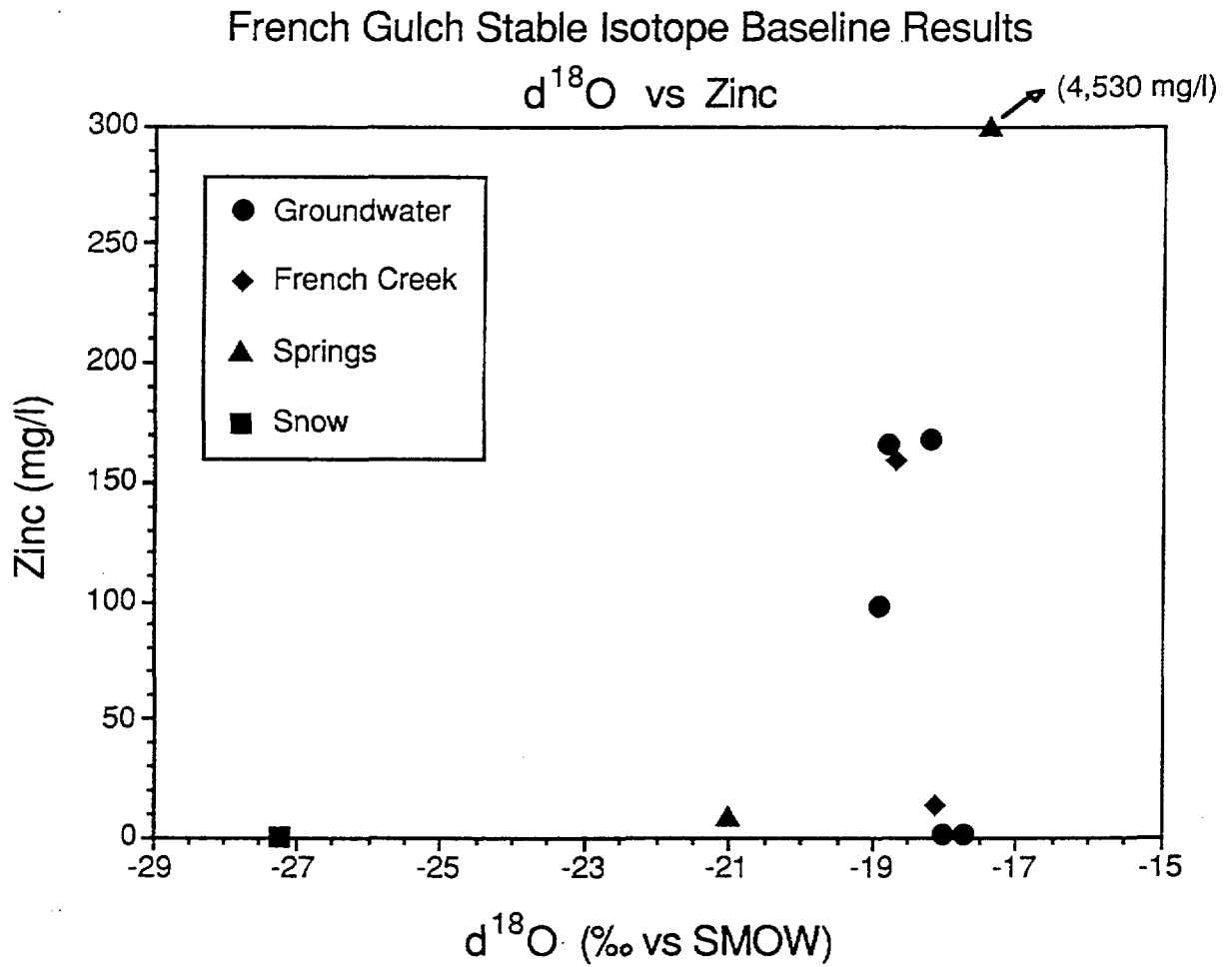


Figure 5.- Oxygen stable isotope composition vs zinc concentrations in snow, surface waters and groundwaters at French Gulch



**Stable Isotopic Investigation of a Snowmelt Event in  
French Gulch, CO**

**Phase II Final Report**

**Prepared by  
Isotope Solutions  
for  
Radon Abatement Systems, Inc.**

**October, 1996**

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## Stable Isotopic Investigation of a Snowmelt Event in French Gulch, CO

### Phase II Final Report

#### Introduction

When rain or snowmelt interacts with sulfide-bearing rocks, oxidation of sulfide minerals can produce acid solutions charged with heavy metals that may be toxic to organisms living in nearby streams and other surface water bodies. In many mining areas in the Western U.S., well developed low-temperature sulfate alteration attests to interactions between groundwaters and sulfide-bearing rocks producing acid solutions for tens or hundreds of thousands of years or more. In cases such as these, the huge scale of the "toxic runoff" phenomenon may limit remediation strategies to those focusing on fluid management and water treatment. It is arguable that mining companies are accountable for environmental problems that arise from natural processes (such as groundwater interactions with naturally occurring sulfide-bearing rocks) unless mining activities have somehow exacerbated the situation.

In other mining areas, "toxic runoff" may be caused by precipitation or snowmelt interacting with surface debris such as mine tailings or overburden piles that have been exposed to surface waters directly through mining activities. This type of "toxic runoff" is likely to be of smaller scale than the natural groundwater/host rock interactions described above and effective remedial designs might include engineering approaches, such as capping and surface water diversion. It is more defensible to argue that mining companies should be held accountable for environmental problems when mining activities can be demonstrated to cause "toxic runoff". In mining areas affected by "toxic runoff", therefore, it is important to distinguish between the two scenarios outlined above.

This investigation was designed to resolve the roles of groundwater and surface waters in a "toxic runoff" event associated with the major Spring snowmelt in a portion of French Gulch, CO. The field investigation was conducted in two phases. Phase I was carried out to provide baseline stable isotopic and geochemical information on groundwaters and surface waters (springs, creeks, snowpack) in the area. Phase I sampling was conducted on March 20, 1996, prior to the beginning of the Spring melting event. We conducted a Phase II investigation based on the very high likelihood of success suggested by the Phase I data.

In Phase II, groundwaters and surface waters from twelve sites were sampled three times during the snowmelt event of the Summer of 1996. Water samples were analyzed for oxygen and hydrogen isotopic composition, as well as Cadmium, Iron, and Zinc concentration. Field measurements included depth to groundwater, water temperature, and electrical conductivity.

#### Analytical Methods and Notation

Oxygen isotope ( $^{18}\text{O}/^{16}\text{O}$ ) and hydrogen isotope ( $^2\text{H}/^1\text{H}$ , or D/H) ratios are measured on an automated gas-source mass spectrometer. Water samples for O-isotope analysis are inlet directly into an automated, computer driven gas equilibration system attached to the mass spectrometer. Hydrogen gas samples are prepared for D/H ratio analysis using conventional reduction methods over zinc beads in closed tubes or equivalent method. The hydrogen gas is inlet to the mass spectrometer through an automated inlet system. Analytical reports are automatically printed and electronically filed in the mass spectrometer computer system.

## Isotope Solutions

Cadmium, Iron, and Zinc concentrations were determined by Inductively Coupled Plasma (ICP) spectrometry and are reported as ppm (~mg/l).

All stable isotopic data are reported using delta ( $\delta$ ) notation, expressing parts per thousand (‰ or per mil) differences between the isotope ratio of the sample and that of the standard, V-SMOW:

$$\delta^{18}\text{O} \text{ or } \delta\text{D} = ((R_s - R_{\text{V-SMOW}}) / R_{\text{V-SMOW}}) \times 1000, \text{ where}$$

$R = {}^{18}\text{O}/{}^{16}\text{O}$  or  $\text{D}/\text{H}$ ,

$S$  = sample, and

V-SMOW = Vienna Standard Mean Ocean Water.

Typical analytical uncertainties (standard deviations from the mean) in the  $\delta^{18}\text{O}$  and  $\delta\text{D}$  values of water samples using the methods and instrumentation described above are  $\pm 0.1$  and  $1.0$  ‰, respectively at the  $2\sigma$  (95%) confidence level.

### Sampling Locations

The sampling locations for this investigation are presented in Table 1, below. Phases I and II of this investigation included four periodic samplings of these sites (rising flow, peak flow, and decreasing flow).

Table 1 - Sampled Sites for French Gulch Stable Isotope Investigation

Sample Type	Location	Comments
Groundwater	MW #14	Clean, 11-10 fault, shale bedrock
Groundwater	MW #9	Clean, lower Qal, upgradient from mine
Groundwater	MW #16	Contaminated, shale bedrock at mine site
Groundwater	MW #3	Contaminated, alluvial, below mill tailings
Mine Water	#3 Mine	Relief Well
Spring water		Kenny Dog Spring, upgradient from mine
Mine waste water	Soil Boring	At Roaster Fines
French Creek		At Country Boy Mine, upstream from site
French Creek		At 6C
French Creek		Downstream from mine site
French Creek		At Dead Elk Pond
Snow	Grab sample	At MW-9 location

## Results

Tables 2, 3, and 4 show the results of metals, stable isotopic, and field measurements, respectively, carried out in this investigation. Time series plots for all French Gulch samples are shown in Appendix 1 of this report. Analytical reports for metals and stable isotope measurements can be found in Appendices 2 and 3, respectively.

## Implications of Phase I Results

The stable isotopic results for Phase I samples, collected on 3/20/96 at a time of minimum water levels and low stream flow are shown on Figure 1. All Baseline samples fall on or near the global meteoric water line (MWL), indicating that the data are reasonably accurate and precise, and that none of the samples has suffered significant evaporation. The position of the two spring samples slightly to the right of the global MWL, however, may indicate minor evaporation (Figure 1).

The isotopic similarity of local groundwaters and samples from French Creek indicates that the principal source of water in the Creek in mid-winter is groundwater. The strong stable isotopic contrast between local groundwaters and samples from French Creek ( $\delta^{18}\text{O} = -18.3 \pm 0.6 \text{ ‰}$ ) and the mid-winter snowpack ( $\delta^{18}\text{O} = -27.2 \text{ ‰}$ ) provides considerable isotopic contrast for conducting isotopic mass balance studies during the snowmelt event. Given the analytical uncertainty of  $\pm 0.1 \text{ ‰}$  for O-isotopic data on water samples, it is possible to estimate snowmelt vs groundwater contributions to French Creek during the snowmelt event with an accuracy of approximately 2% (as illustrated below). The  $\delta^{18}\text{O}$  and  $\delta\text{D}$  values covary linearly as with all meteoric waters. Further discussions of stable isotope data, therefore, will focus solely on the oxygen isotope compositions.

The distinctive stable isotopic composition of the Baseline Kenny Dog Spring sample indicates that the spring waters contained a significant proportion of local snowmelt. Field observations at the time of sampling (W. Pedler, pers. comm. to BMS) are consistent with this conclusion. If it is assumed that (1) Kenny Dog Spring water had an original  $\delta^{18}\text{O}$  value of  $-17.4 \text{ ‰}$  (identical to most  $^{18}\text{O}$ -rich French Creek and local groundwater samples measured in this investigation), and (2) French Gulch snowmelt had a  $\delta^{18}\text{O}$  value of  $-27.2 \pm 0.1 \text{ ‰}$  (as measured), then the calculated proportion of snowmelt in the Kenny Dog Spring sample ( $\delta^{18}\text{O} = -21.0 \pm 0.1 \text{ ‰}$ ) is  $37 \pm 2\%$ . If the Kenny Dog Spring sample is diluted with 37% surface snowmelt (with essentially no Cd, Fe, and Zn), then the metals concentrations should be shifted upward to correct for the dilution (i.e., divided by 0.63). This example illustrates the isotopic mass balancing capabilities for simple, two-component water mixtures.

Although there are strong correlations between metals contamination, low pH, and high electrical conductivity, there is no striking correlation between metal concentrations and stable isotope composition of French Gulch surface waters and groundwater samples in mid-winter (Figures 2a - 2c). Under the hydrologic conditions in which the Baseline investigation was conducted (late winter with no significant snowmelt), both the Creek and the springs have isotopic compositions similar to local groundwater. Contaminated groundwaters, therefore, are likely to have been responsible for the mid-winter metal contamination measured in one of the French Creek samples. Other contaminated surface waters such as the waste waters at the Roaster Fines, also have stable isotopic compositions similar to local groundwater in mid-winter.



Table 2. Metals Data for French Gulch Water Samples

Sample	Location	Baseline (3/20/96)			Second (6/10/96)		
		Cd (ppm)	Fe (ppm)	Zn (ppm)	Cd (ppm)	Fe (ppm)	Zn (ppm)
FG 1, 13	MW-14	0.013	1.7	0.39	0.01	5.9	1.7
FG 2, 12	MW-9	<0.005	0.51	0.092	0.0054	0.46	0.13
FG 3, 18	MW-16	0.046	99.3	96.8	0.072	120	127
FG 4, 16	MW-3	0.12	211	167	0.34	297	277
FG 5, 17	#3 Relief	0.2	188	165	0.63	169	230
FG 6, 20	FC6C spring	0.14	201	159	0.54	165	355
FG 7, 19	KennyDog Spr.	0.072	16.7	8.4	0.017	2.1	9.6
FG 8, 15	Roaster Fines3	<0.5	26,900	4,530	13	4,090	3,160
FG 9, 14	FCreek @ CB	<0.005	2.2	0.4	nd	nd	nd
FG 11, 21	FG7,LowerFC	0.027	1.3	13.4	0.0089	0.64	2.6
FG 22	FG8DeadElkPd	ND	ND	ND	0.0064	0.16	0.76

ND = Not Determined

nd = not detected

Sample	Location	Third (6/27/96)			Fourth (7/22/96)		
		Cd (ppm)	Fe (ppm)	Zn (ppm)	Cd (ppm)	Fe (ppm)	Zn (ppm)
FG 24, 37	MW-14	0.0075	15.7	4.3	nd	15.1	4.6
FG 23, 36	MW-9	nd	nd	nd	nd	0.51	0.17
FG 26, 38	MW-16	0.092	117	124	0.058	94.5	106
FG 28, 35	MW-3	0.31	279	256	0.17	338	243
FG 27, 39	#3 Relief	0.72	184	242	0.53	144	199
FG 30	#3 Mine	0.68	164	232	ND	ND	ND
FG 32, 43	FC6C spring	0.61	163	328	0.34	334	285
FG 29, 41	KennyDog Spr.	0.011	11.2	7.9	nd	2.8	6.1
FG 25, 40	Roaster Fines3	15.2	3,750	3,360	13.6	3,940	3,260
FG 31, 42	FCreek @ CB	nd	0.18	0.048	nd	nd	0.025
FG 33, 44	FG7,LowerFC	0.0074	0.28	2.7	0.0073	0.27	4.2
FG 34, 45	FG8DeadElkPd	nd	0.13	0.66	nd	0.13	0.59

ND = Not Determined

nd = not detected

Table 3. Stable Isotope Data for French Gulch Water Samples

Oxygen Isotopes:Delta O-18		First	Second	Third	Fourth
Sample	Location	3/20/96	6/10/96	6/27/96	7/22/96
FG 1,13, 24, 37	MW-14	-17.7	-18.1	-18.8	-18.4
FG 2,12, 23, 36	MW-9	-18.0	-17.9	-18.0	-17.4
FG 3,18, 26, 38	MW-16	-18.9	-18.6	-18.8	-18.6
FG 4,16, 28, 35	MW-3	-18.2	-18.4	-18.6	-18.6
FG 5,17, 27, 39	#3 Relief	-18.8	-18.5	-18.8	-18.7
FG30	#3 Mine	ND	ND	-18.7	ND
FG10	Snow at MW-9	-27.2	ND	ND	ND
FG 6, 20, 32, 43	FC6C spring	-18.7	-18.5	-18.6	-18.0
FG 7,19, 29, 41	Kenny Dog Spr.	-21.0	-18.6	-18.7	-18.7
FG 8,15, 25, 40	Roaster Fines3	-17.4	-17.8	-17.8	-17.8
FG 9,14, 31, 42	FCreek @ CB	-18.0	-18.1	-17.8	-17.8
FG 11, 21, 33, 44	FG7, LowerFC	-18.1	-18.1	-18.2	-17.8
FG 22, 34, 45	FG8 DeadElkPd	ND	-18.0	-18.1	-17.9

ND =Not Determined

Hydrogen Isotopes:Delta D		First	Second	Third	Fourth
Sample	Location	3/20/96	6/10/96	6/27/96	7/22/96
FG 1,13, 24, 37	MW-14	-132	-134	-142	-131
FG 2,12, 23, 36	MW-9	-131	-136	-137	-122
FG 3,18, 26, 38	MW-16	-141	-144	-145	-135
FG 4,16, 28, 35	MW-3	-136	-143	-139	-135
FG 5,17, 27, 39	#3 Relief	-141	-143	-144	-135
FG30	#3 Mine	ND	ND	-146	ND
FG10	Snow at MW-9	-206	ND	ND	ND
FG 6, 20, 32, 43	FC6C spring	-141	-143	-139	-136
FG 7,19, 29, 41	Kenny Dog Spr.	-159	-144	-141	-142
FG 8,15, 25, 40	Roaster Fines3	-133	-130	-137	ND
FG 9,14, 31, 42	FCreek @ CB	-132	-136	-127	-126
FG 11, 21, 33, 44	FG7, LowerFC	-132	-137	-127	-127
FG 22, 34, 45	FG8 DeadElkPd	ND	-136	-127	-125

ND =Not Determined

Table 4. Field Measurements for French Gulch Water Samples

Sample	Location	Baseline (3/20/96)			First (6/10/96)		
		Depth to Water (ft)	Temperature (°C)	Conductivity (μS/cm)	Depth to Water (ft)	Temperature (°C)	Conductivity (μS/cm)
FG 1, 13	MW-14	24.00	8.6	1,885	5.95	10.0	1,879
FG 2, 12	MW-9	20.80	5.0	260	17.35	4.8	283
FG 3, 18	MW-16	13.57	10.1	2,450	1.00	9.7	2,790
FG 4, 16	MW-3	16.97	9.4	2,270	14.27	7.8	3,390
FG 5, 17	#3 Relief Well	13.40	8.1	2,420	1.40	10.4	2,860
FG30	#3 Mine	ND	ND	ND	ND	ND	ND
FG 6, 20	FC6C spring	NA	7.6	2,480	NA	11.1	3,110
FG 7, 19	KennyDog Spr.	NA	5.6	80	NA	8.5	613
FG 8, 15	Roaster Fines3	ND	11.2	25,500	5.92	13.3	9,910
FG 9, 14	FCreek @ CB	NA	4.6	180	NA	3.3	86
FG 11, 21	FG7,LowerFC	NA	1.0	395	NA	3.6	155
FG 22	FG8DeadElkPd	ND	ND	ND	NA	3.9	119

NA = Not Applicable

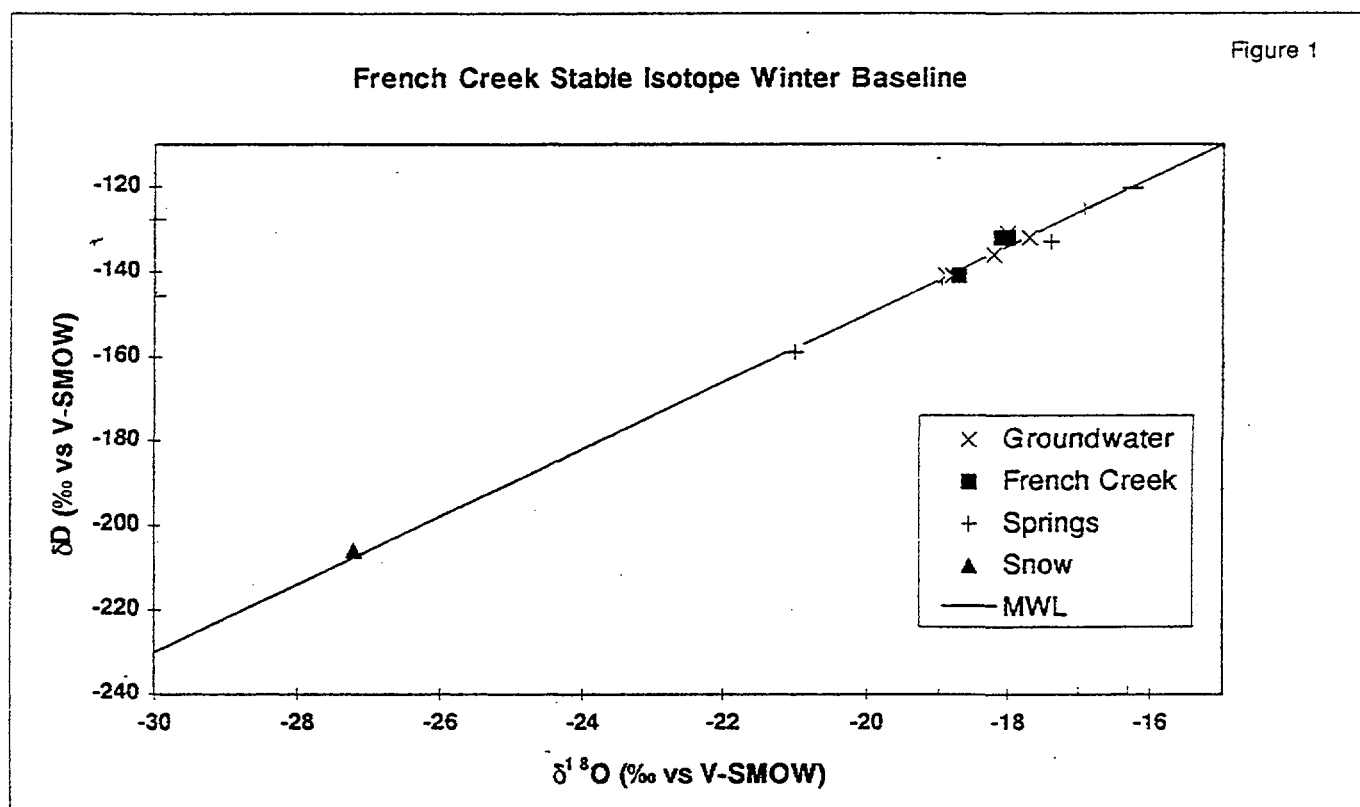
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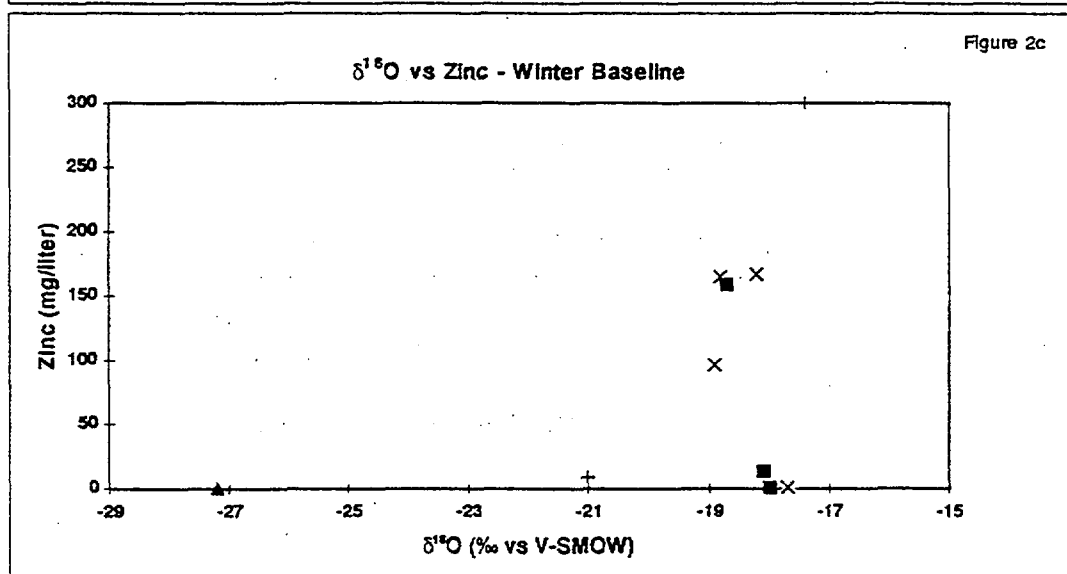
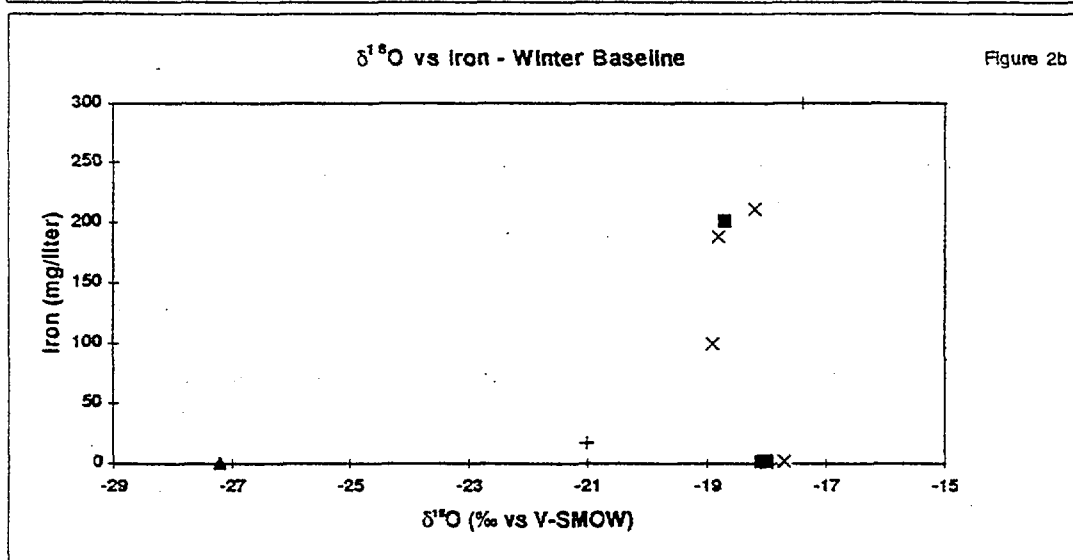
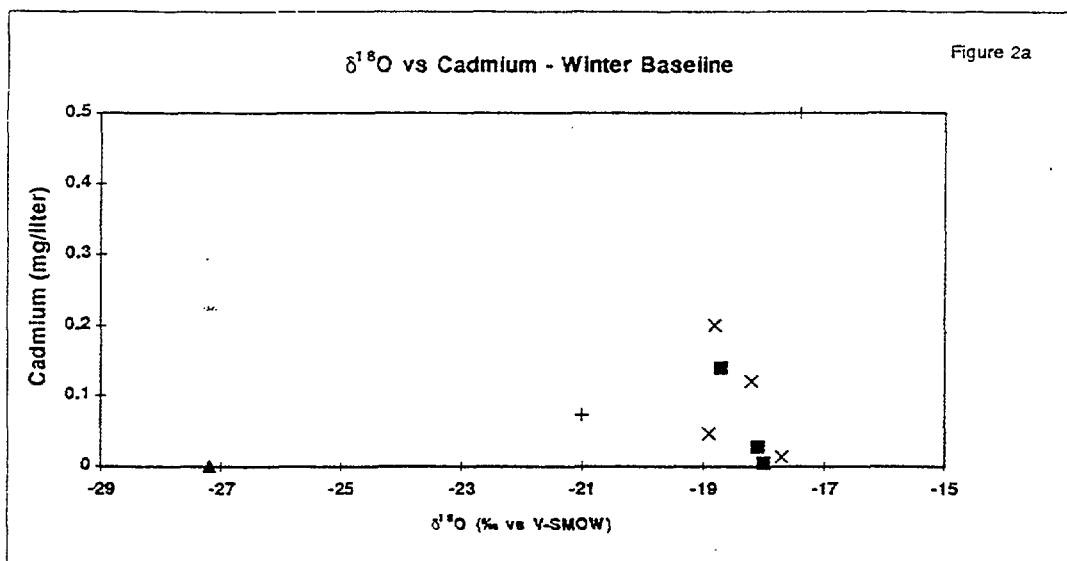
Sample	Location	Second (6/27/96)			Third (7/22/96)		
		Depth to Water (ft)	Temperature (°C)	Conductivity (μS/cm)	Depth to Water (ft)	Temperature (°C)	Conductivity (μS/cm)
FG 24, 37	MW-14	9.88	6.8	1,739	14.45	10.4	1,912
FG 23, 36	MW-9	18.80	6.6	320	18.84	8.0	316
FG 26, 38	MW-16	2.95	10.3	2	6.32	11.2	2,129
FG 28, 35	MW-3	14.78	8.1	2,240	15.75	8.5	2,370
FG 27, 39	#3 Relief Well	1.47	9.9	1,959	3.96	11.4	2,060
FG30	#3 Mine	NA	8.8	1,927	ND	ND	ND
FG 32, 43	FC6C spring	NA	9.9	2,350	NA	7.7	2,380
FG 29, 41	KennyDog Spr.	NA	7.3	391	NA	9.3	425
FG 25, 40	Roaster Fines3	6.49	12.5	9,080	8.45	13.1	9,840
FG 31, 42	FCreek @ CB	NA	5.2	52	NA	7.6	71
FG 33, 44	FG7,LowerFC	NA	7.7	103	NA	11.3	162
FG 34, 45	FG8DeadElkPd	NA	6.5	75	NA	9.8	98

NA = Not Applicable

ND = Not Determined

Sample Location	Baseline pH
MW-14	6.26
MW-9	7.06
MW-16	5.53
MW-3	5.39
#3 Relief	5.55
FC6C spring	5.35
KennyDog Spr.	6.32
Roaster Fines3	2.23
FCreek @ CB	6.30
FG7,LowerFC	6.03





### Changes in Water Levels during the Snowmelt Event

Figure 3 shows the relative changes in water level for the five wells sampled during this investigation plotted against the number of days since the Baseline sampling. This figure reveals that:

- Three wells (MW-14, MW-16, and #3 Relief) in the shale aquifer showed a marked increase in water level during the first 60 days.
- The two wells (MW-3 and MW-9) in the alluvial aquifer showed a less pronounced increase in water level.
- The peak water levels occurred approximately 60 days after the Baseline sampling. Thereafter, water levels begin to return to low-flow conditions, a process that will apparently be complete ~160 days after the Baseline sampling (i.e., in early September, 1996).

### Oxygen Isotopic Response to the Snowmelt Event

Figures 4a and 4b (detail) illustrate the oxygen isotopic compositions of well, spring, and French Creek samples through four samplings extending over four months, from the Baseline mid-winter sampling (3/20/96) to mid-summer (7/23/96). The only sample that shows a large oxygen isotopic shift from the Baseline value is that from Kenny Dog Springs, which had a  $\delta^{18}\text{O}$  value indicating considerable contamination with local snowmelt during the Baseline sampling. In all subsequent samplings, however, the spring yielded water that was isotopically similar to the lowest- $^{18}\text{O}$  groundwater, spring, and stream samples. Thus, the post-baseline samples from Kenny Dog Springs were not particularly contaminated with local snowmelt.

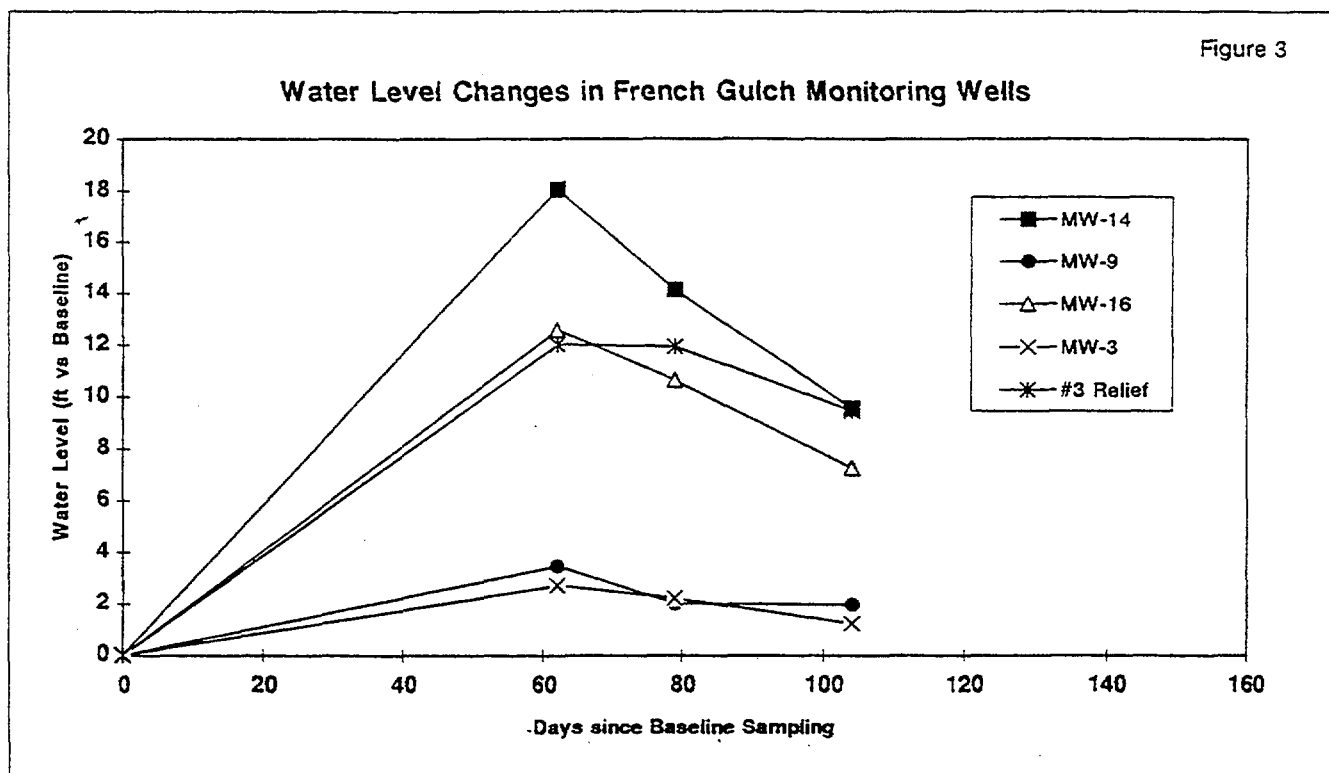
The most striking aspect of the data shown on Figures 4a and 4b is the near uniformity in stable isotopic composition of all French Gulch samples over time, despite the fact that the following events were occurring during the period of sampling:

- The local snowpack was lost to sublimation and melting, with concomitant infiltration, evaporation, and runoff,
- French Creek crested to much higher flow rates and began to recede, and
- Water levels in local monitoring wells rose substantially and began to recede.

### Evidence for Minimal Contributions of Snowmelt to French Creek and Local Aquifers

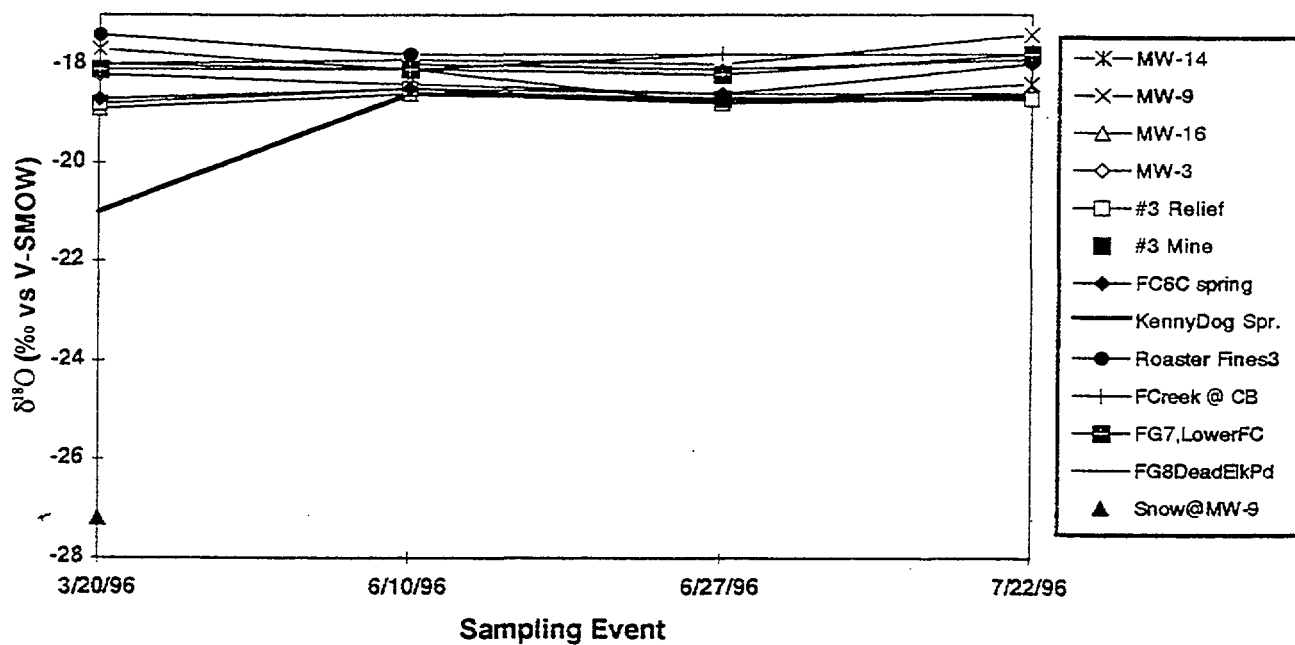
Figure 5 shows the maximum amount of local snowmelt ( $\delta^{18}\text{O} = -27.2\text{‰}$ , the measured value for local snow) than could have mixed with local "end member" groundwater with a  $\delta^{18}\text{O}$  of  $-17.4\text{‰}$  (the highest measured value for French Gulch groundwater and spring water samples). Apart from the Baseline sample from Kenny Dog Springs, groundwaters, spring waters, and French Creek water samples could have a maximum of ~15% snowmelt at the height of the snowmelt event. It is, however, probable that snowmelt contributes an even smaller percentage of the total water flowing in French Creek, given that the stable isotopic compositions of French Creek samples changed so little during the four sampling events. Indeed, the very small changes in the oxygen isotopic compositions of French Creek samples from low-flow through high-flow conditions (Figure 5) indicates that the proportion of snowmelt could only represent a few percent,

Figure 3



French Gulch Oxygen Isotope Trends

Figure 4a



French Gulch Oxygen Isotope Trends (detail)

Figure 4b

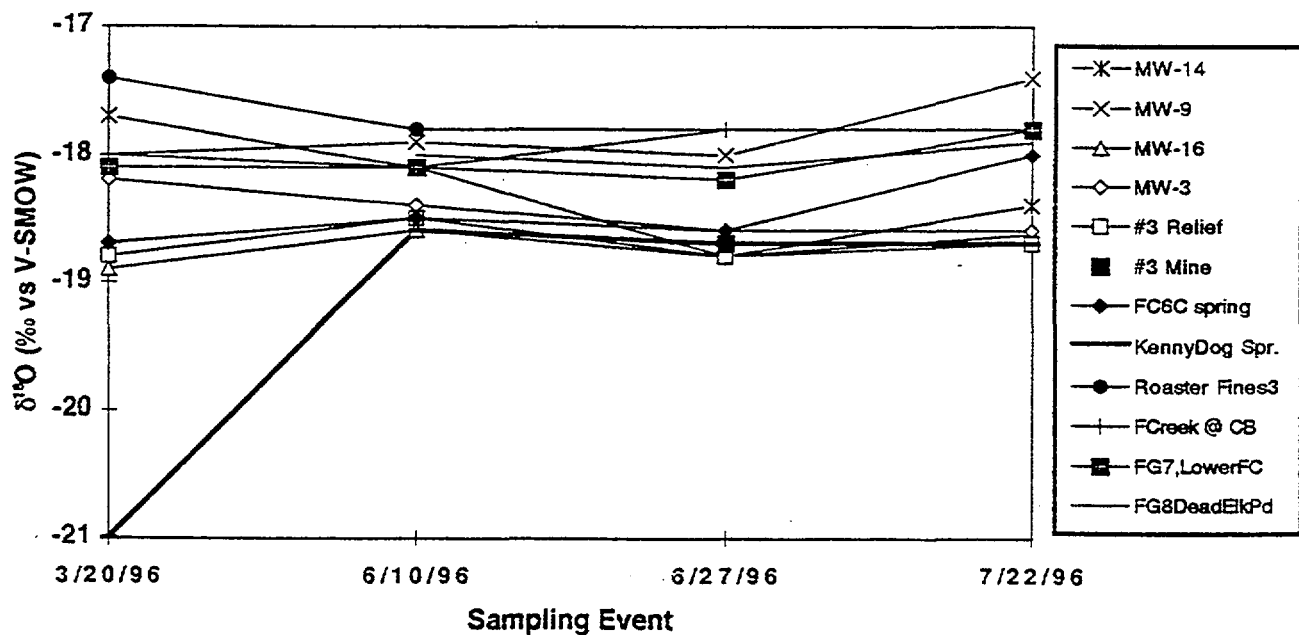
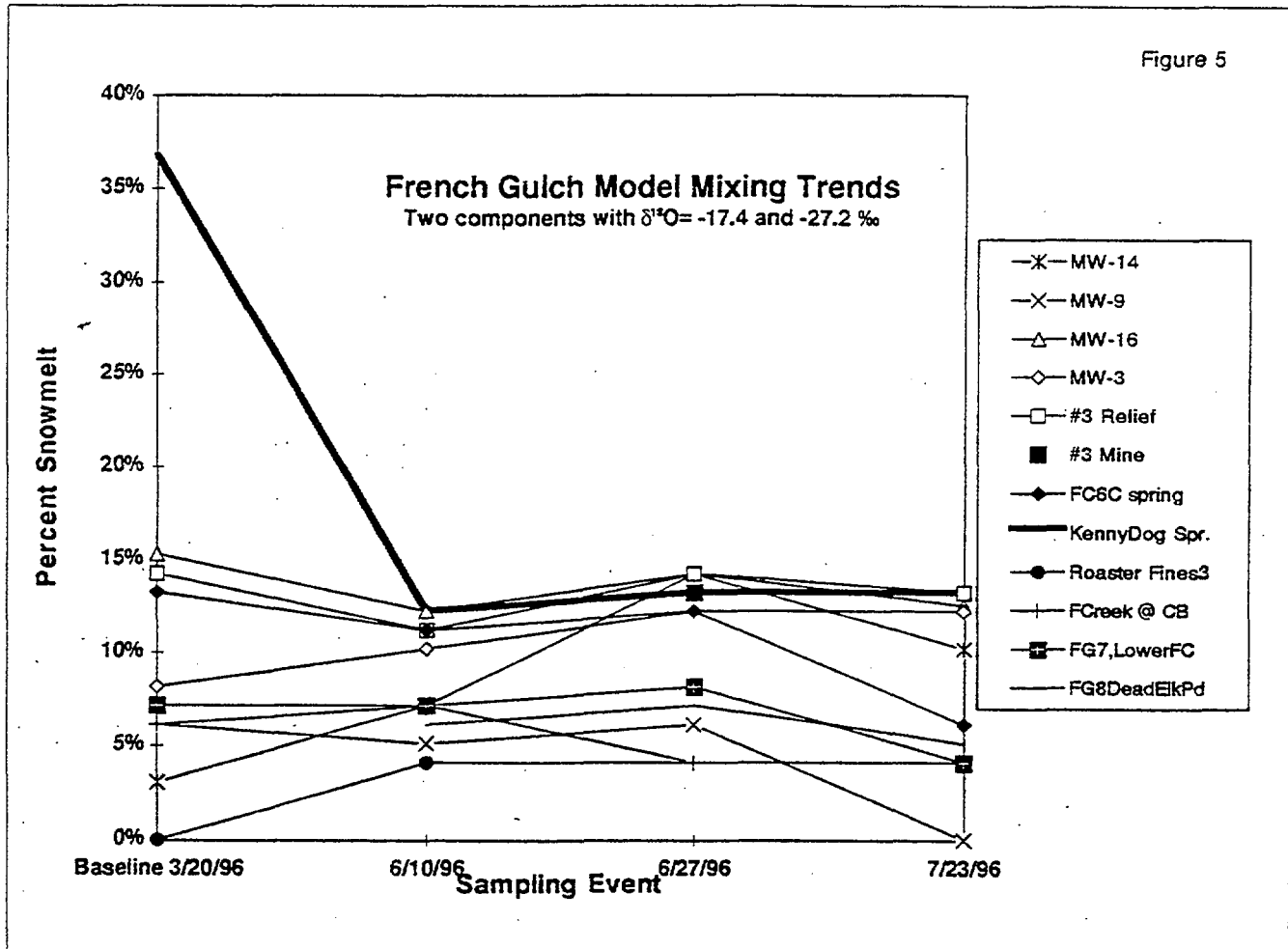




Figure 5



that is, near the limit of resolution of the rather sensitive stable isotopic methods we are using in this investigation.

The remarkable oxygen isotopic uniformity in the French Gulch samples indicates the following:

1. Snowmelt contributed only a small proportion of the water responsible for increased flow in French Creek during the period of sampling, and
2. The bulk of the water flowing in French Creek during the June crest had an oxygen isotopic composition comparable to that of local groundwater and springs.

### Stable Isotopic Groupings

Despite the general uniformity in the stable isotopic compositions of French Gulch water samples, small but consistent differences in the  $\delta^{18}\text{O}$  values shown on Figures 4a and 4b indicate that the waters may be grouped by oxygen isotopic composition into three distinctive groups, as follows:

1. An  $^{18}\text{O}$ -rich group that consistently has  $\delta^{18}\text{O}$  values between -17.4 and -18.2 ‰. This group includes the French Creek sites (CB, Dead Elk Pond, and Lower French Creek), monitoring well MW-9 (uncontaminated, alluvial aquifer), and the Roaster Fines site (highly contaminated).
2. An  $^{18}\text{O}$ -depleted group that consistently has  $\delta^{18}\text{O}$  values between -18.5 and -19.0 ‰. This group includes monitoring well MW-16 (contaminated, shale aquifer at mine site), Kenny Dog Springs (post-Baseline samples), and the contaminated #3 Relief well and #3 Mine site.
3. A group of water samples that exhibited small but consistent shifts in oxygen isotope composition with time. This group includes sites that shifted from values similar to the  $^{18}\text{O}$ -rich group to lower values similar to those of the  $^{18}\text{O}$ -poor group (monitoring wells MW-14, uncontaminated shale aquifer and MW-3, contaminated alluvial aquifer). Group 3 also includes French Creek 6C spring, which shows the opposite behavior, changing from a relatively low- $^{18}\text{O}$  signature to a higher- $^{18}\text{O}$  signature over the time of sampling.

Although the above groupings are based on rather small differences in oxygen isotope composition, the isotopic trends serve to constrain conceptual models for the overall water balance in French Gulch and for processes controlling metals contamination in local waters. It is clear, for example, that a model involving the simple mixing of two, isotopically distinct water reservoirs where one of these reservoirs carries metals contamination is too simple to explain the data. It is necessary to examine water levels, metals loading, and stable isotope relations in individual wells and springs to learn more about the mechanisms of metal contamination in French Gulch.

### Evidence for Increased Surface Water Metal Loading during the Snowmelt Event

Figure 6a shows Cd concentrations for French Gulch samples for the four sampling events. Note that the Roaster Fines sample is not plotted because it has a much higher Cd concentration that is off scale compared to the other analyzed samples. Samples from four contaminated sites show slightly (MW-16) to strongly (MW-3, FC6C Spring, and #3 Relief Well and Mine) rising Cd concentrations during the time of rising water levels and rising flow in French Creek, and falling Cd concentrations as the watershed began to return to lower flow conditions. All other

Figure 6a

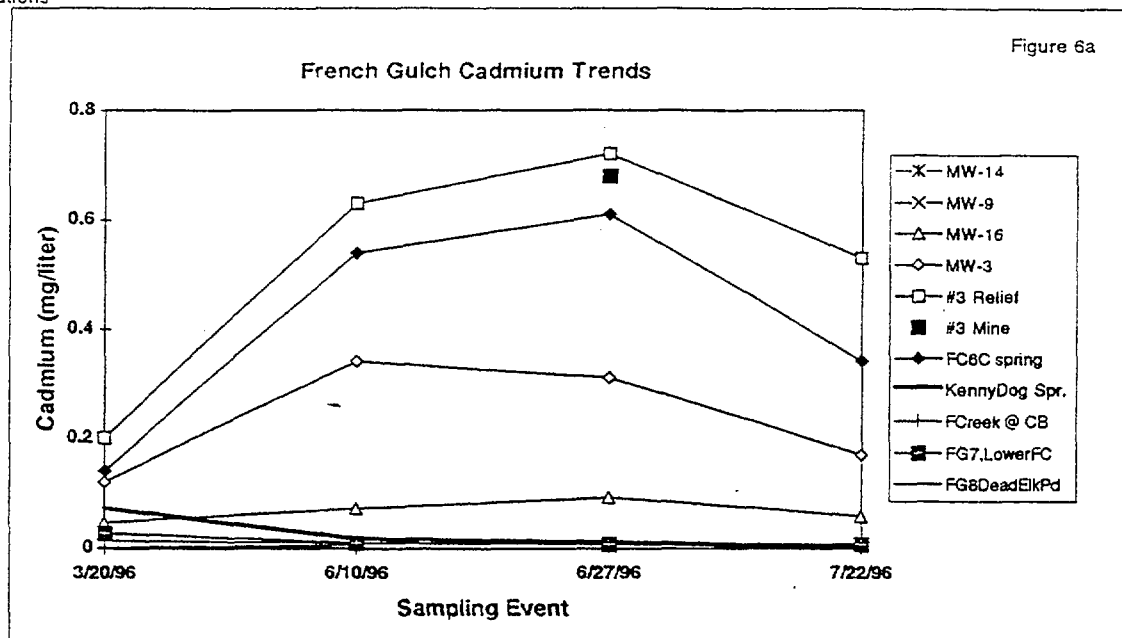


Figure 6b

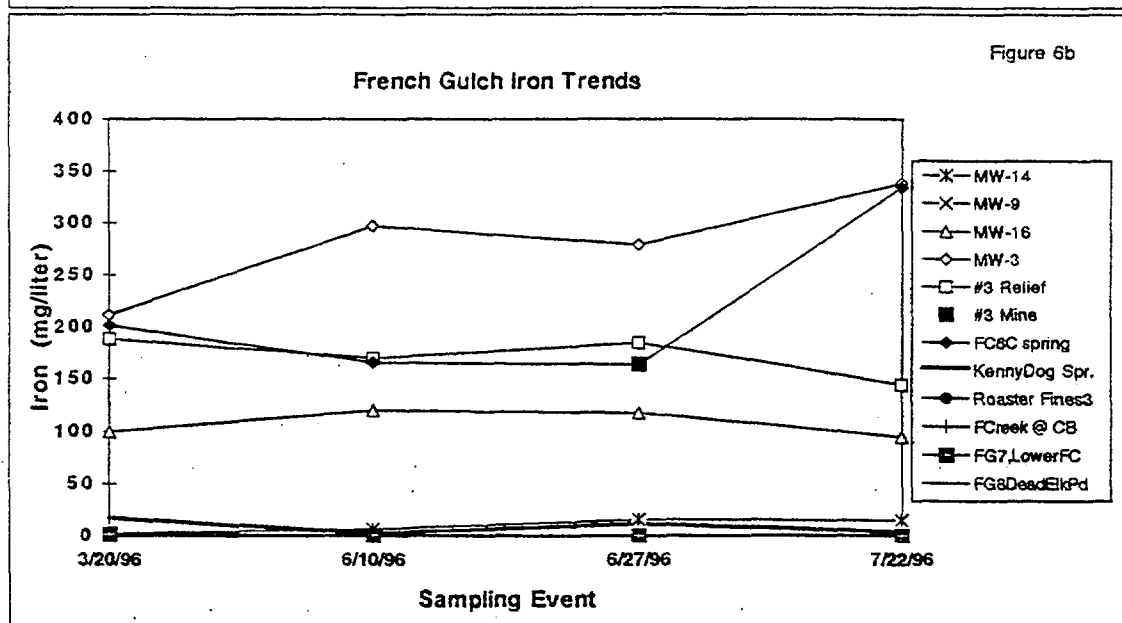
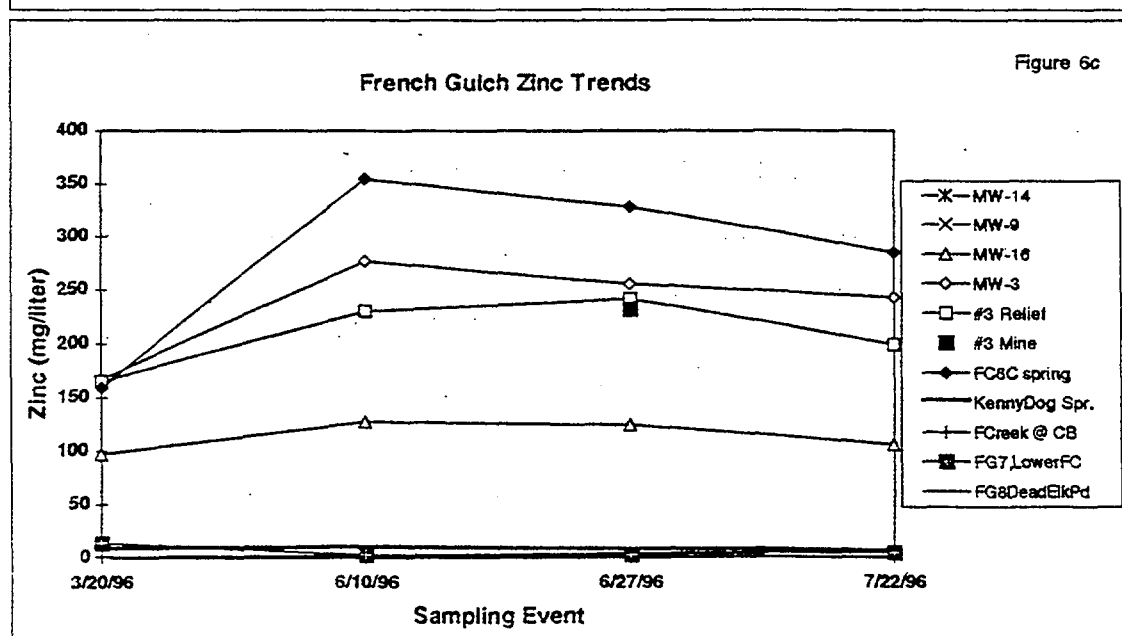


Figure 6c



sampled sites either exhibit falling Cd concentrations (Kenny Dog Spring) or consistently low Cd concentrations.

Figures 6b and 6c show Fe and Zn concentrations, respectively, for French Gulch samples for the four samplings. Again, the Roaster Fines samples are not plotted because they have much higher Fe and Zn concentrations than the other samples. Comparison of Figures 5 with Figures 6a-c indicates that the same four sites show the highest concentrations of Cd, Fe and Zn. In addition, there is a positive correspondence with high water levels in French Gulch monitoring wells (compare with Figure 3) for both Cadmium and Zinc. Iron, however, shows similar or rising concentrations throughout the course of the investigation, implying that Iron loading in French Creek is not fully coupled with Cadmium and Zinc loading.

#### Evidence Against Surface Water Infiltration in Three French Gulch Monitoring Wells

Figure 7 shows the relative changes in oxygen isotope composition of the five monitoring wells in French Gulch. Three of these wells (MW-9, MW-16, and #3 Relief) exhibit either little change in oxygen isotopic signature, or a slightly more  $^{18}\text{O}$ -rich signature as the snowmelt progressed. This is incontrovertible evidence that the water level changes in these three wells did not occur due to vertical infiltration or lateral migration of surface waters derived from melting snow. The water level rise in these wells is probably a response to increased lateral recharge from infiltration occurring somewhere upgradient from the wells. These wells appear to be largely isolated from the local surface, although two of them (MW-16, and #3 Relief) are contaminated.

#### Evidence Supporting Surface Water Infiltration in Two French Gulch Monitoring Wells

Figure 7 also shows that two wells (MW-3 and MW-14) exhibit lower  $\delta^{18}\text{O}$  values during the snowmelt event. It is possible that rising water levels in these wells were caused, at least in part, by local infiltration of snowmelt from the surface. Note that MW-3 is a contaminated alluvial well and the alluvial aquifer in this area may be in hydrologic communication with the surface. In the same sense, MW-14 is an uncontaminated well drilled along a fault which may provide a rapid transport pathway between the surface and the shale aquifer at that site.

Because these two wells exhibit lower  $\delta^{18}\text{O}$  values during high water level conditions, it is possible to model the processes responsible for water level rise and aquifer contamination at these two sites. Figures 8a and 8b show the relative changes in oxygen isotope composition and water level for monitoring wells MW-14 and MW-3, respectively. In the first 60 days after the Baseline sampling, both wells showed rises in water level as well as negative shifts in  $\delta^{18}\text{O}$  value. In the ensuing 17 days, water levels began to decline while  $\delta^{18}\text{O}$  values continued their downward shifts. In the final 25 days between the third and fourth samplings, water levels continued to decline while  $\delta^{18}\text{O}$  values remained stable or reversed to slightly higher  $\delta^{18}\text{O}$  compositions. The patterns displayed on Figures 8a and 8b are remarkably similar and suggest the following:

- During the initial 60 days, the rising water levels could be the result of a combination of higher rates of lateral recharge and infiltration of small amounts of low- $^{18}\text{O}$  snowmelt from the surface.
- During the ensuing 17 days, recharge from low- $^{18}\text{O}$  surface waters (snowmelt) continued, while lateral recharge declined.
- During the final 25 days, both surface and groundwater recharge continued to decline.

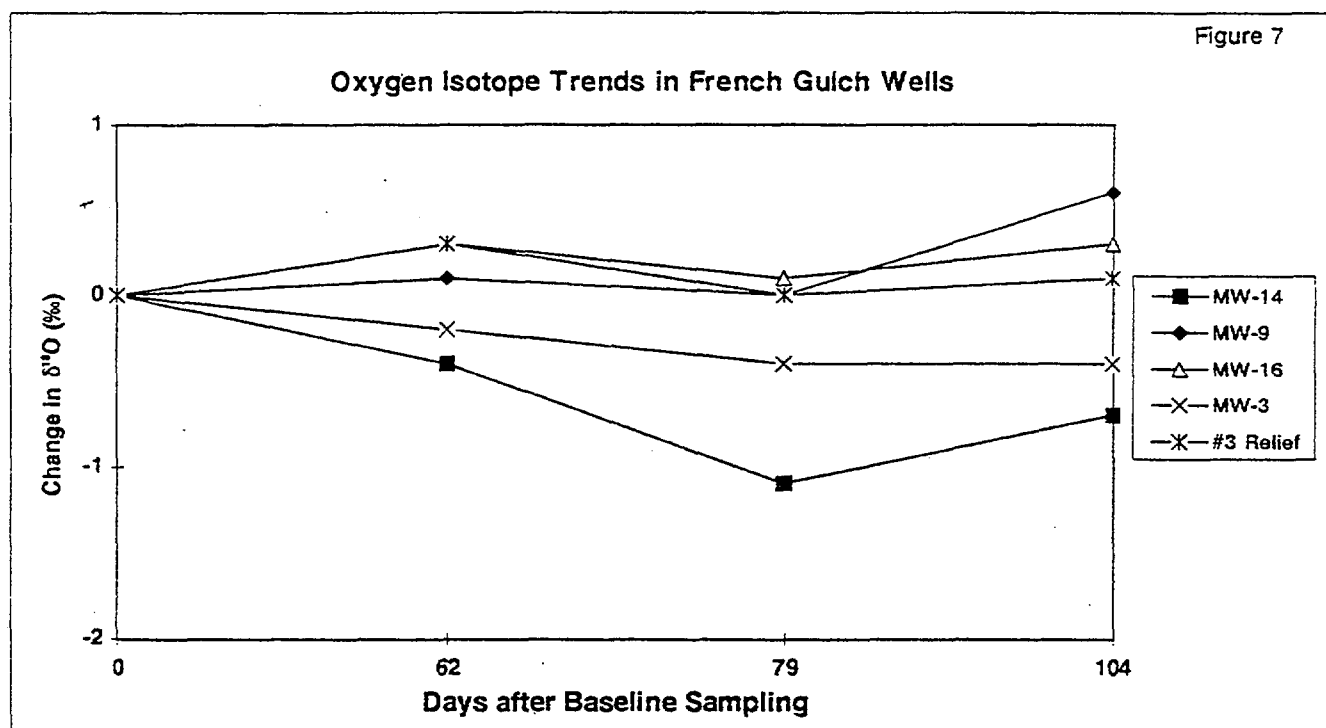


Figure 8a

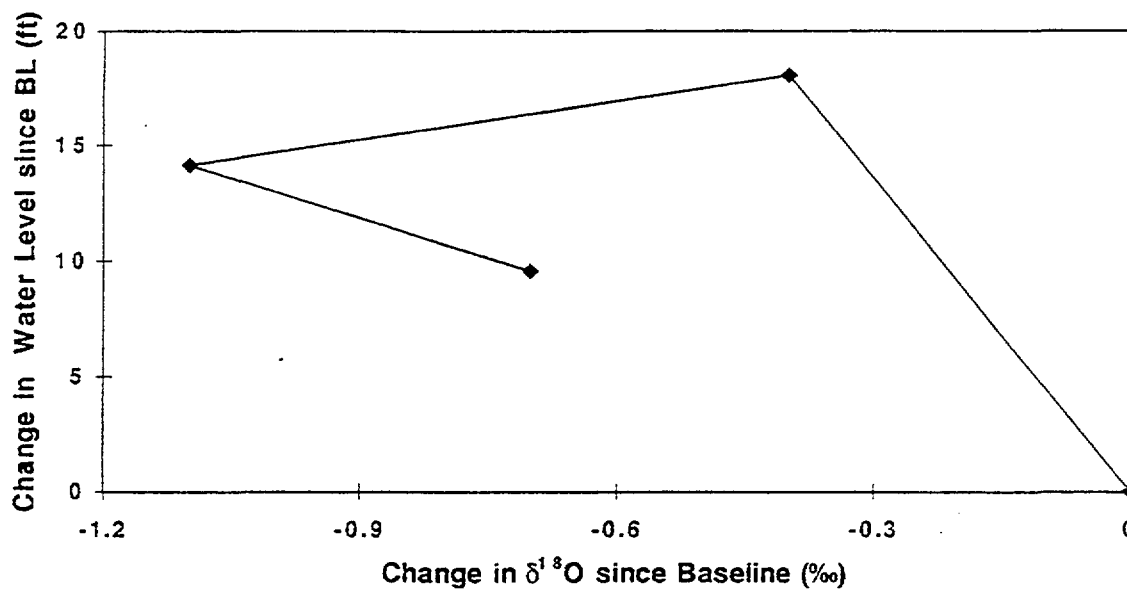
Relative  $\delta^{18}\text{O}$  and Water Level Shifts: MW-14

Figure 8b

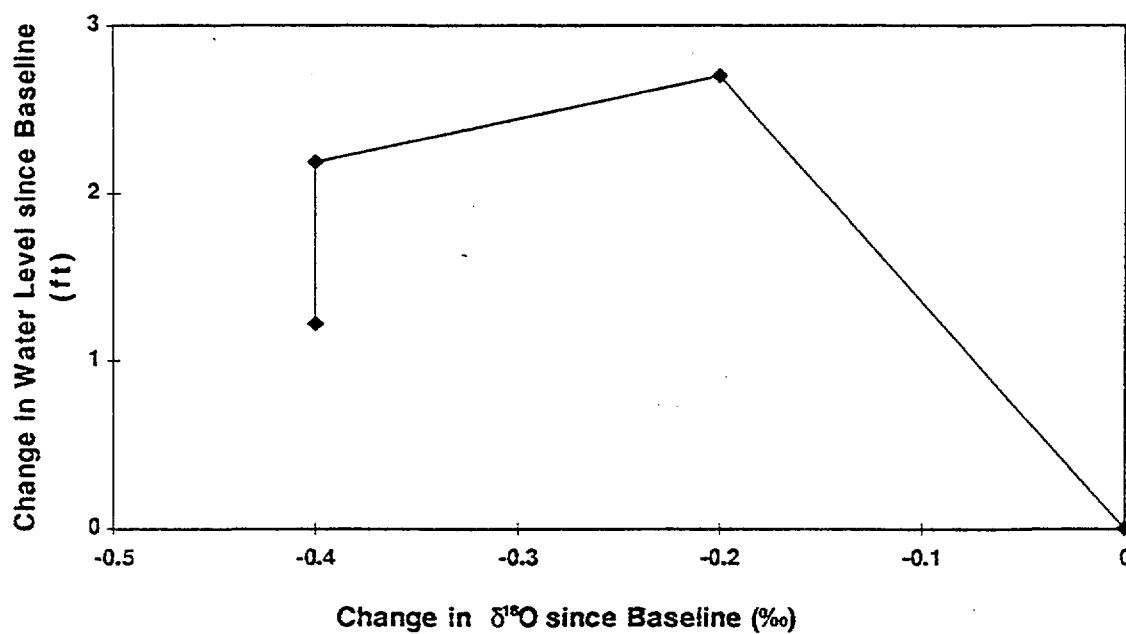
Relative  $\delta^{18}\text{O}$  and Water Level Shifts: MW-3

Figure 9a

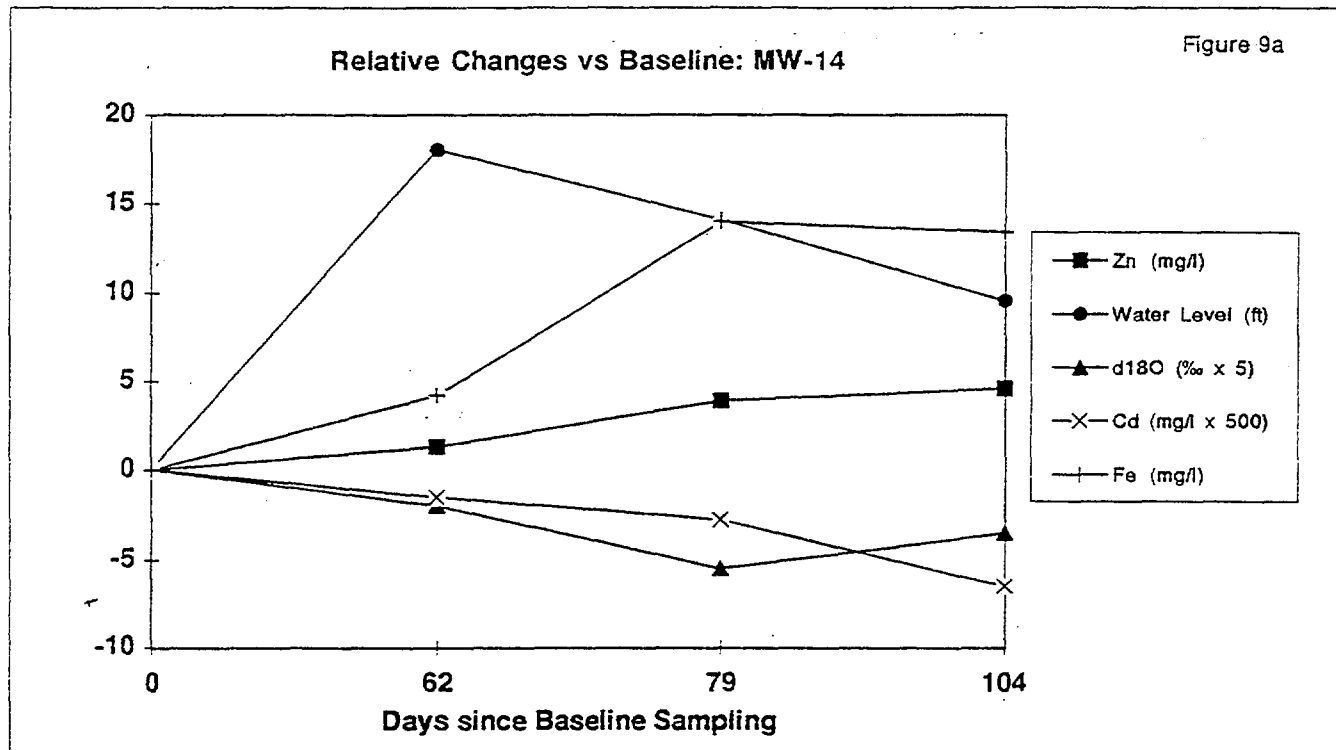
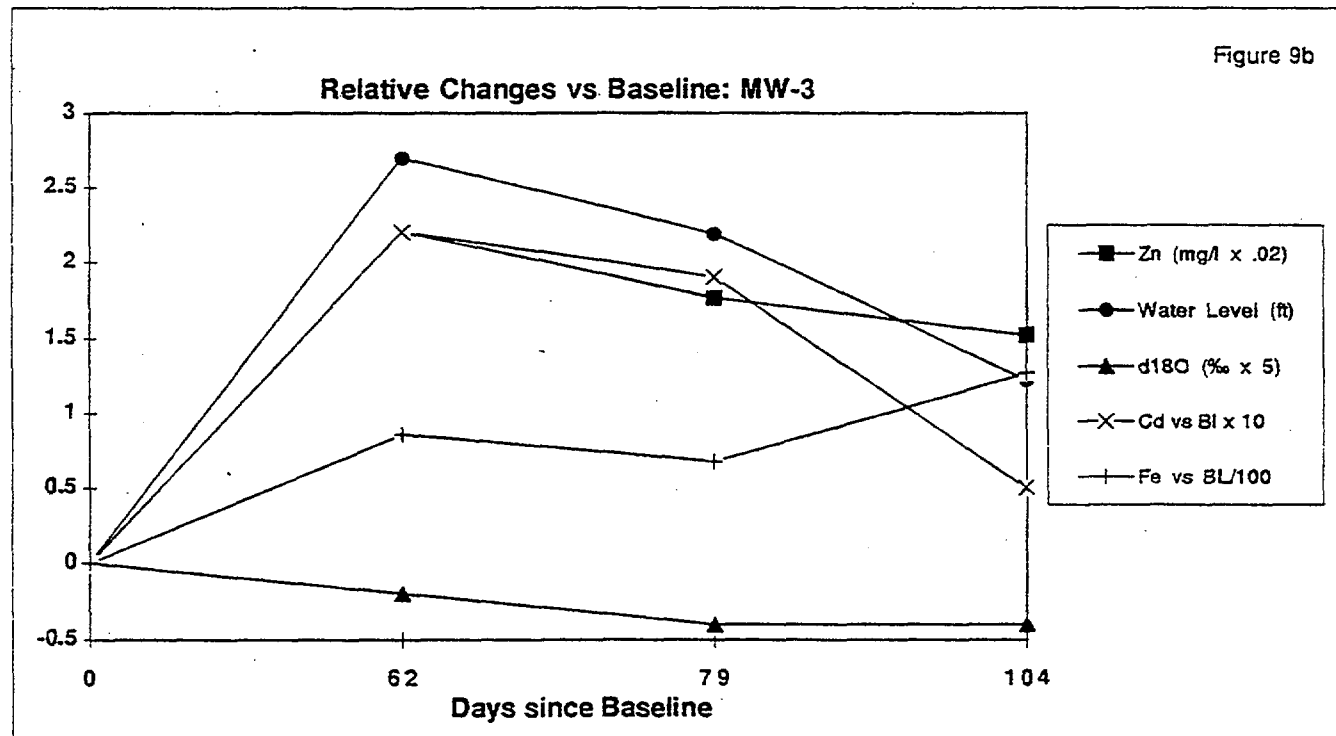


Figure 9b



#### Evidence Supporting Surface Water Involvement in Metals Contamination at MW-14

Figure 9a shows that Zinc concentrations in monitoring well MW-14 rose from their Baseline values through the first 62 days since the Baseline sampling, while water levels were rising and low- $^{18}\text{O}$  snowmelt was being added to the aquifer by infiltration from above. In the ensuing 17 days, however, Zinc concentrations continued to rise while the water level was falling. Note that the  $\delta^{18}\text{O}$  value was continuing to fall, suggesting that contaminated snowmelt may be responsible for the Zinc contamination in this well.

#### Evidence against Surface Water Involvement in Metals Contamination at MW-3

In contrast to MW-14, Figure 9b shows a strong correlation between water level and Zinc concentration in monitoring well MW-3. In this case, Zinc concentrations began to fall between days 62 and 79, despite the continued decreases in the  $\delta^{18}\text{O}$  value of the water. This suggests that the Zinc contamination originates through subsurface interactions between groundwater and sulfide-rich rocks at this site, despite the proximity to mill tailings at the surface.

#### Recommendations

1. Sampling of all French Gulch sites should be performed after the watershed has returned to low flow conditions. Conducting this sampling will allow investigation of the "relaxation" phase in the watershed, where water levels in monitoring wells and in French Creek will continue to fall due to reduced subsurface hydrostatic pressures (in general) and reduced infiltration of surface waters (at some sites).
2. A more detailed investigation of French Gulch should be carried out in the Spring and Summer of 1997. This investigation should follow the same general approach as the present investigation, but should include all available sampling sites (springs, seeps, wells) in the area. This level of detail is required to understand the various mechanisms of metals contamination, and to identify all "point sources" for stable isotopic and geochemical analysis.
3. Remedial strategies should be designed after the detailed stable isotopic and geochemical investigation in 1997. Because several different mechanisms for metals contamination have been identified in this initial study, it may not be possible to remediate the metals contamination problem in French Gulch using a single approach. Instead, a combination of engineering and water treatment approaches may be required, depending on the origin of the contamination at each site. For example, contamination from infiltrating surface waters might be remediated through removal of sulfide materials at the surface or through isolation techniques such as capping. Groundwaters contaminated through subsurface interactions with sulfide bearing rocks are not amenable to such engineering techniques, and treatment methods may be required to remove contamination from some French Gulch waters.

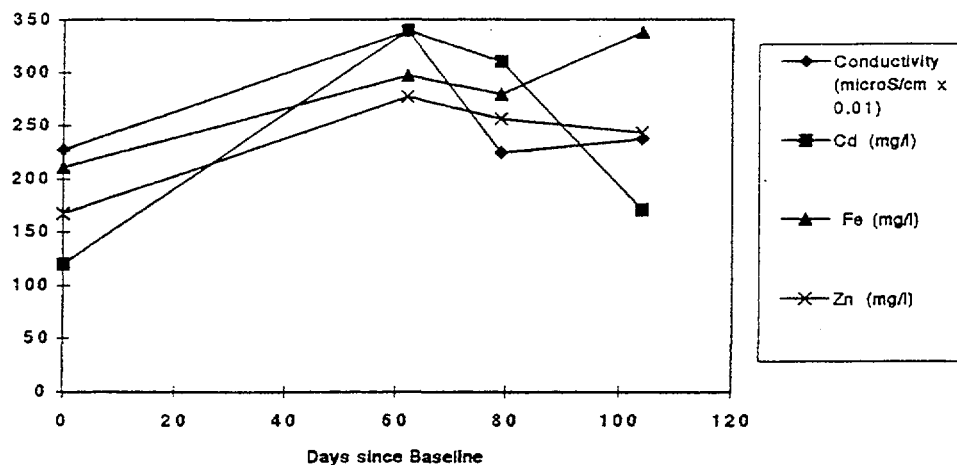


## **Appendix 1**

### **Time Series Plots for French Gulch Phase I and Phase II Sampling Sites**

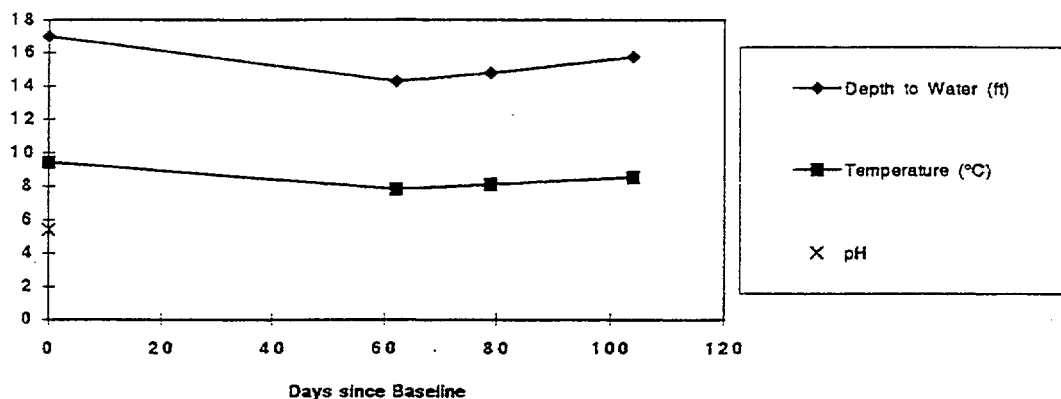
Metals and Conductivity Trends: MW-3

Figure A1-1a



Geophysical Trends: MW-3

Figure A1-1b



Oxygen Isotope Trends: MW-3

Figure A1-1c

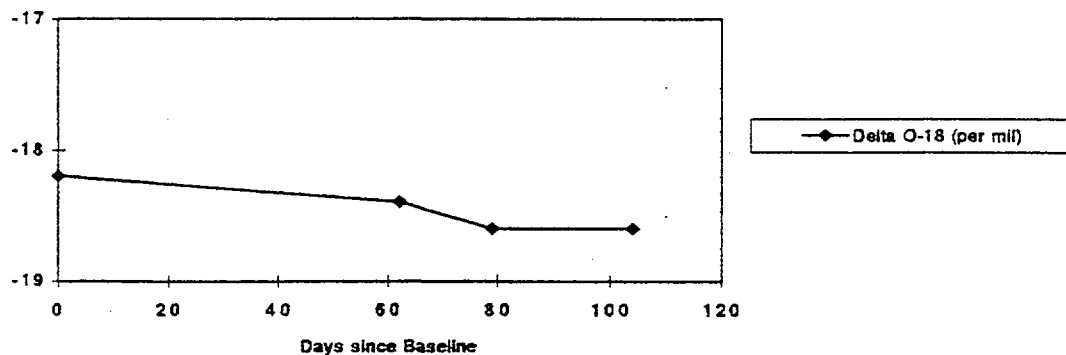


Figure A1-2a

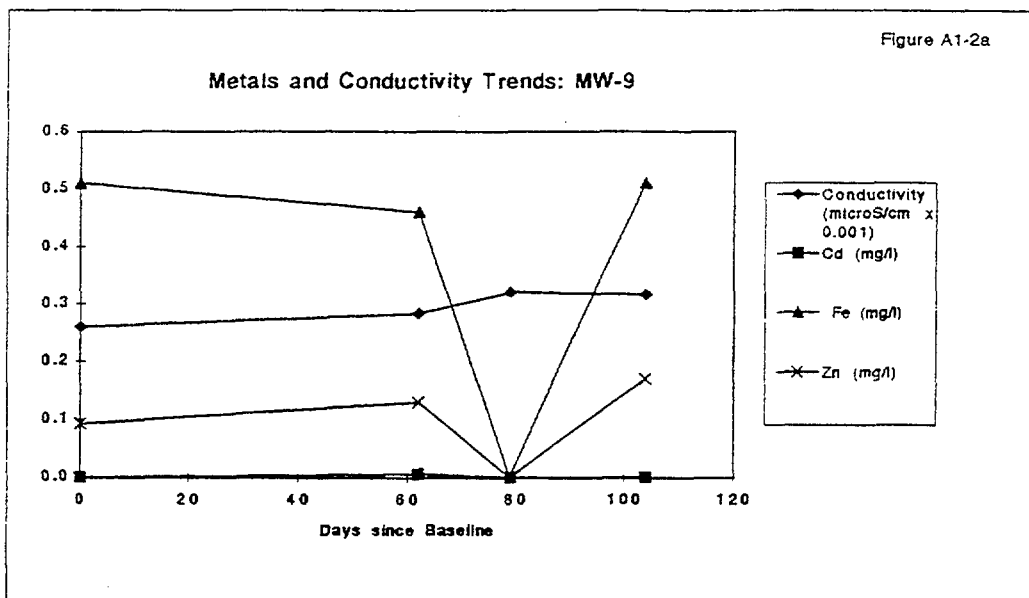


Figure A1-2b

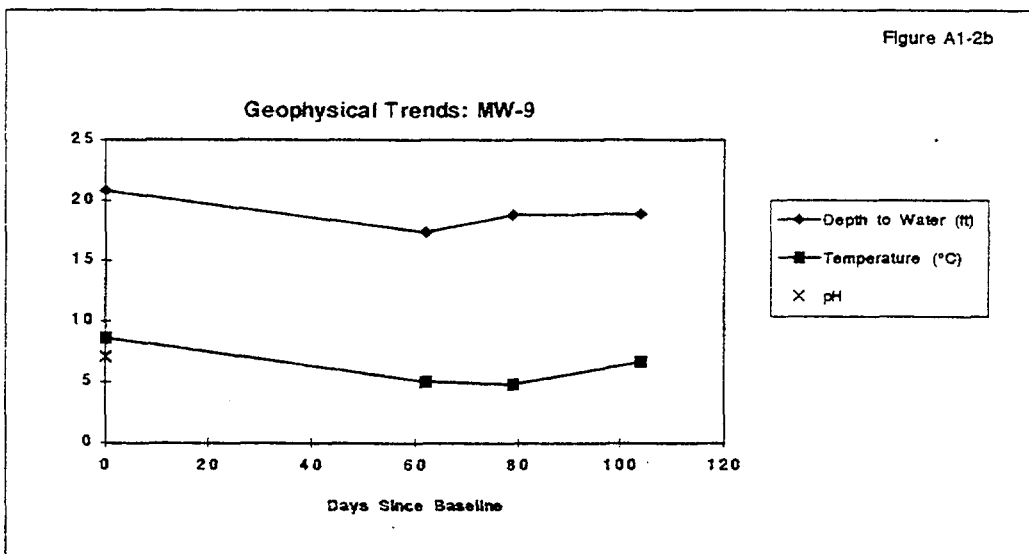


Figure A1-2c

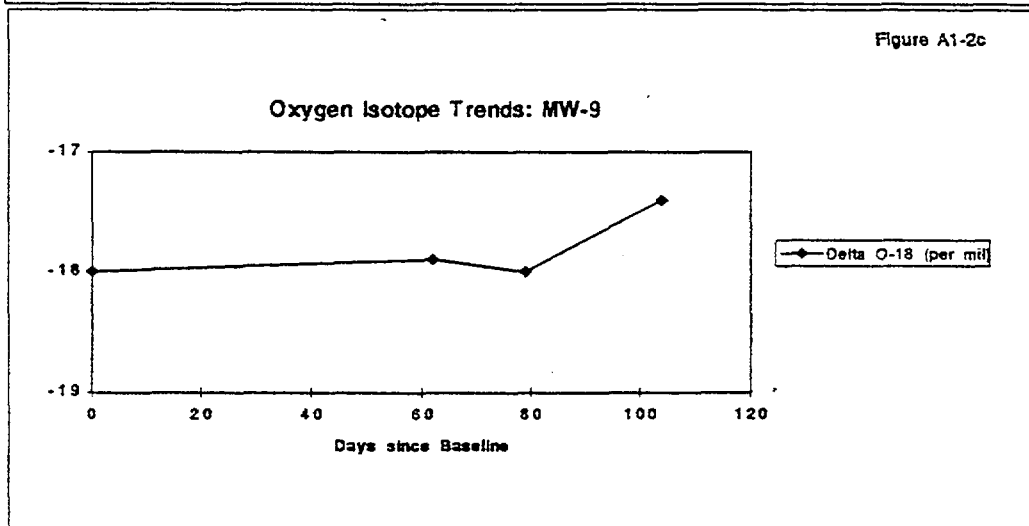


Figure A1-3a

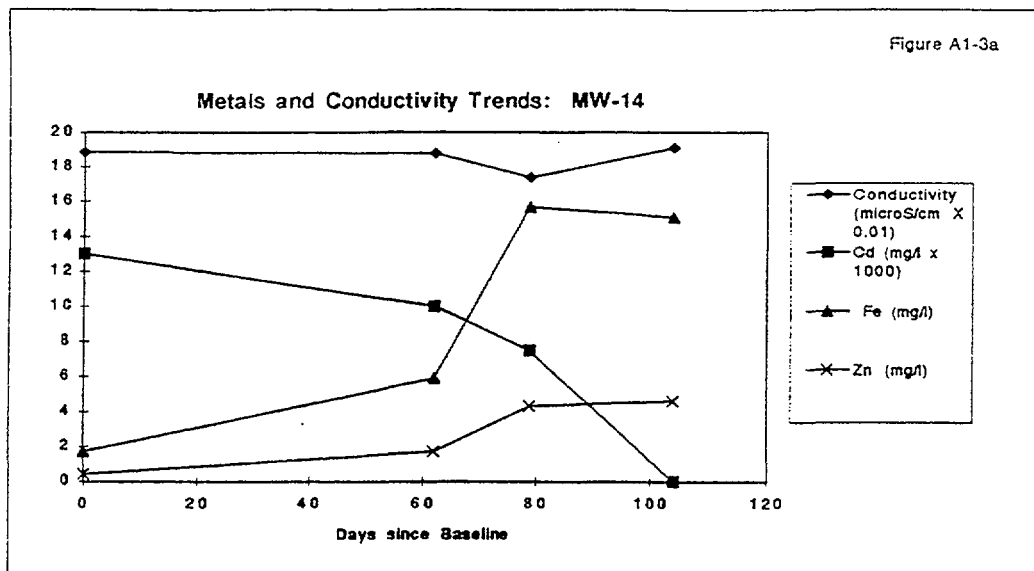


Figure A1-3b

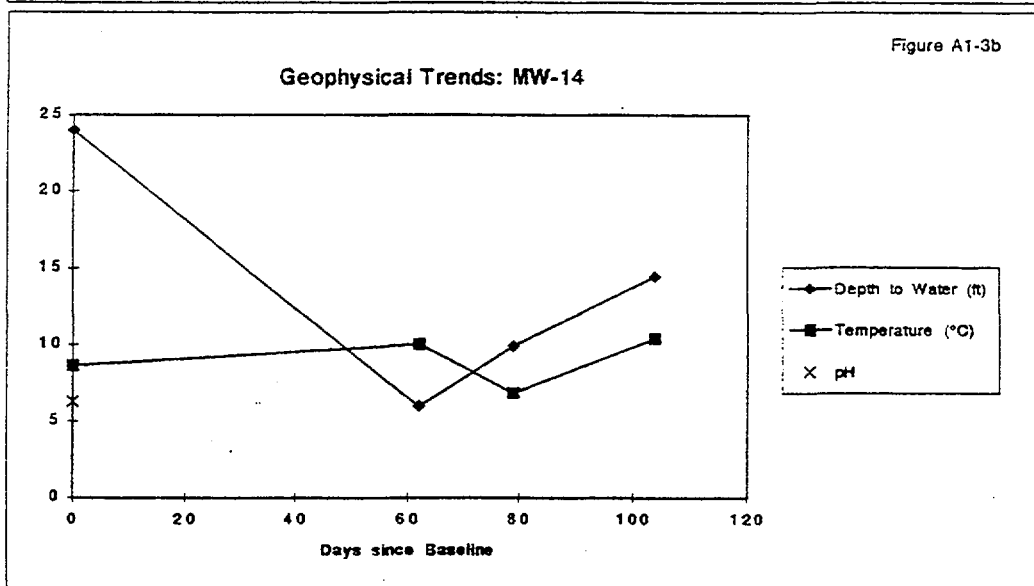


Figure A1-3c

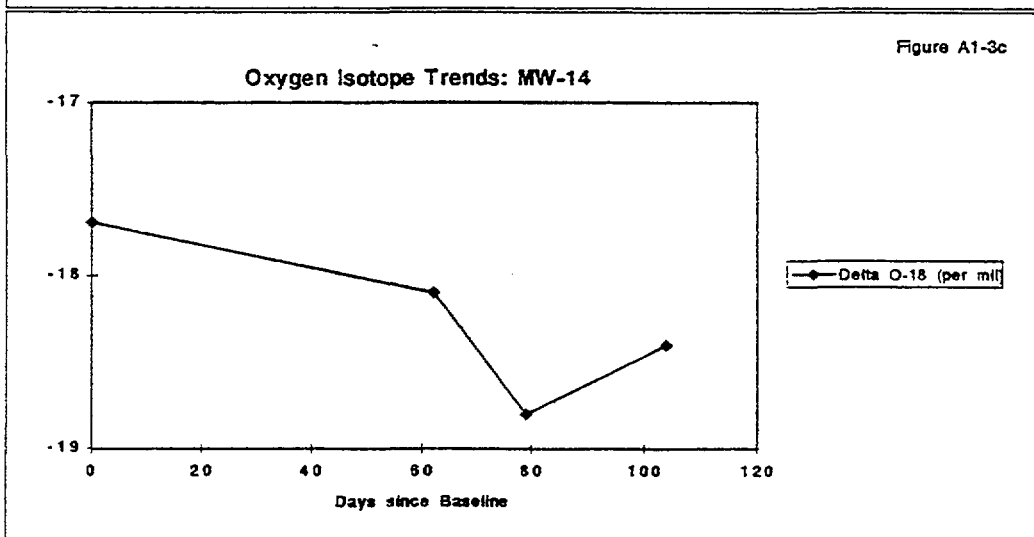


Figure A1-4a

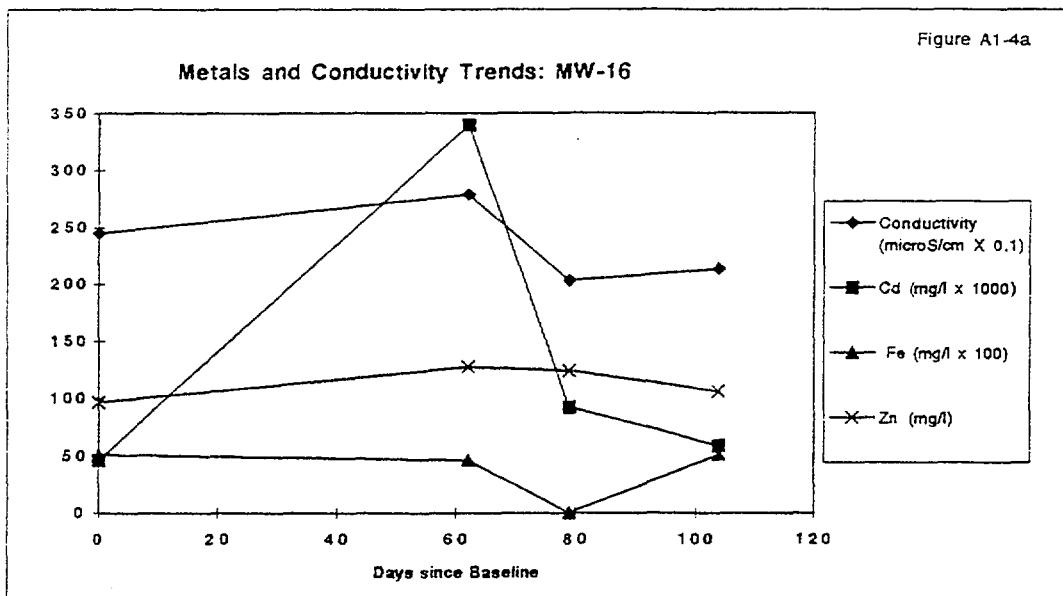


Figure A1-4b

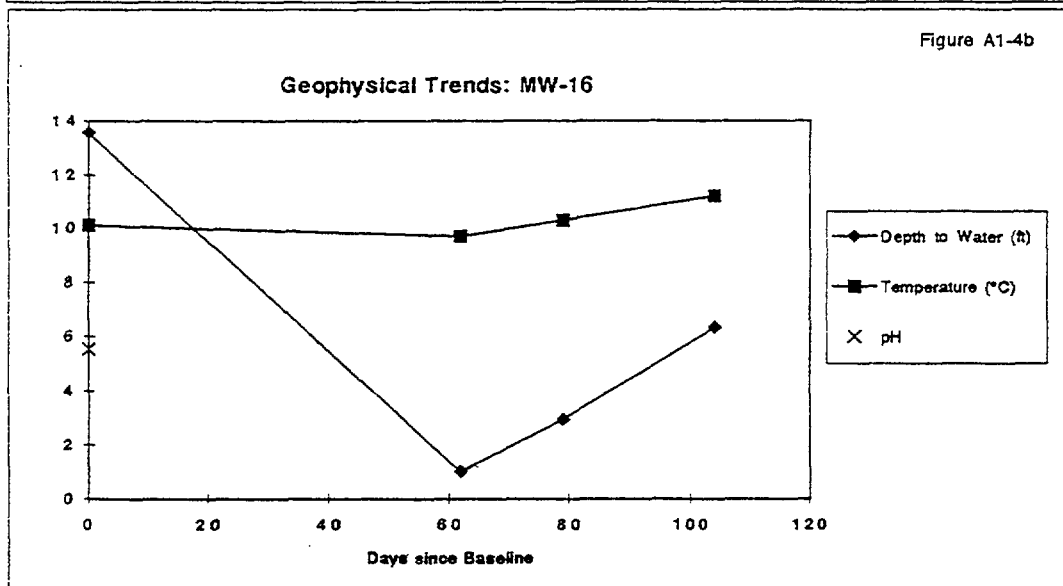
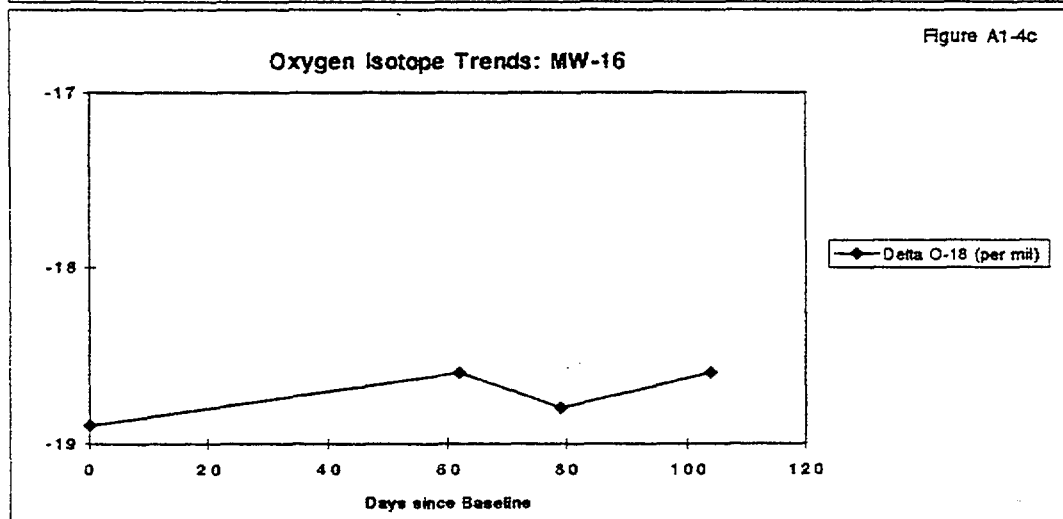


Figure A1-4c



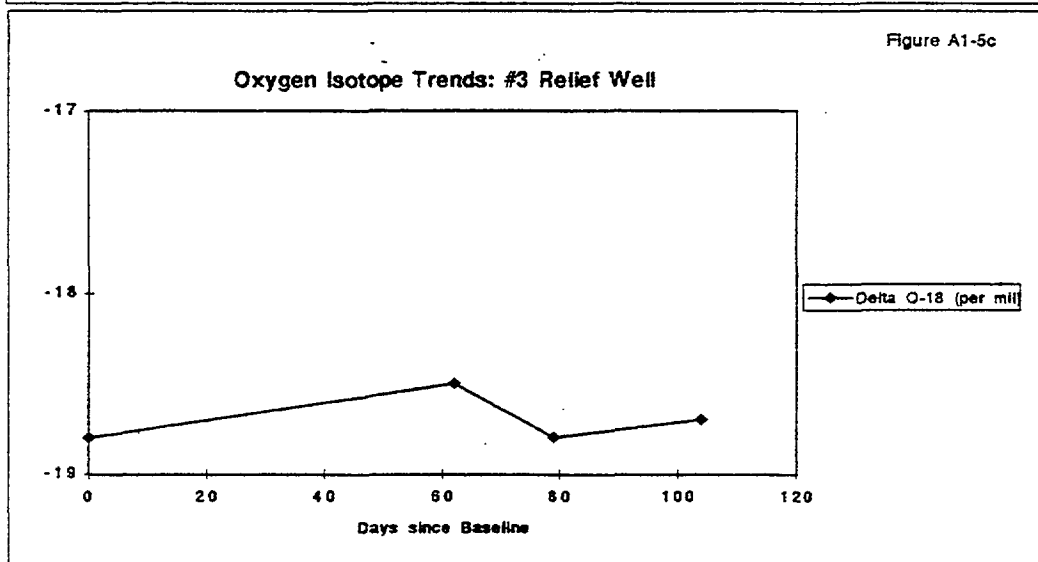
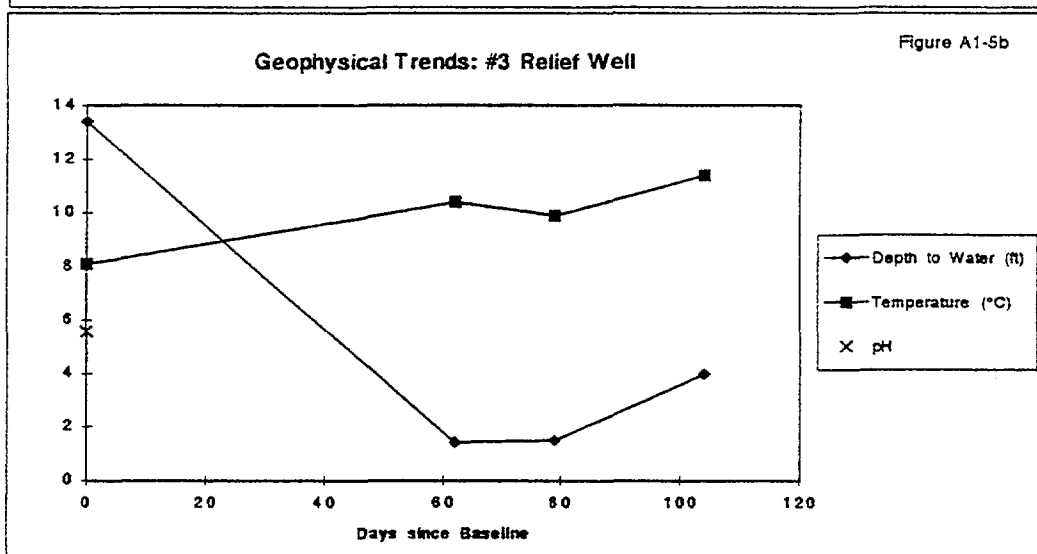
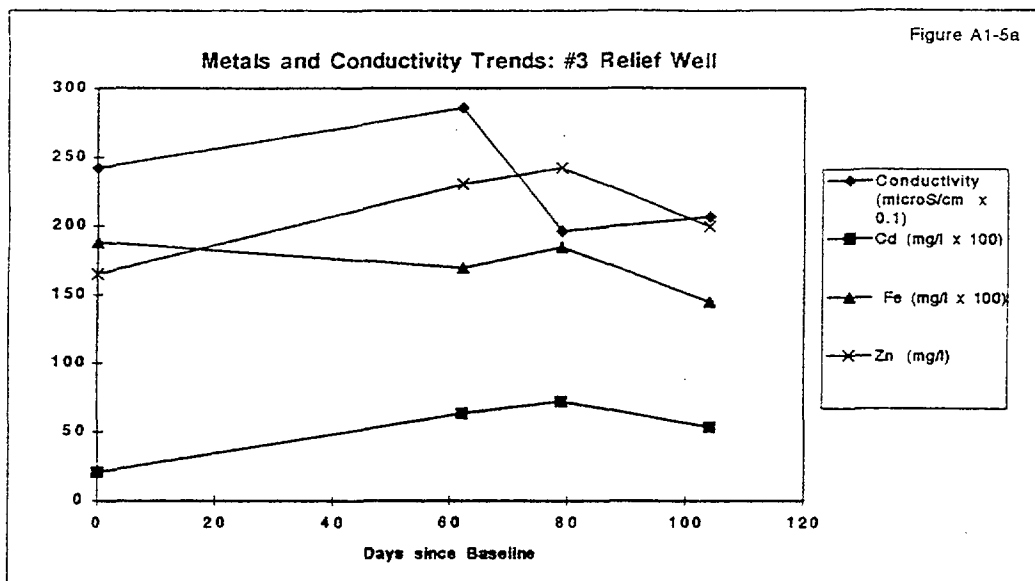


Figure A1-6a

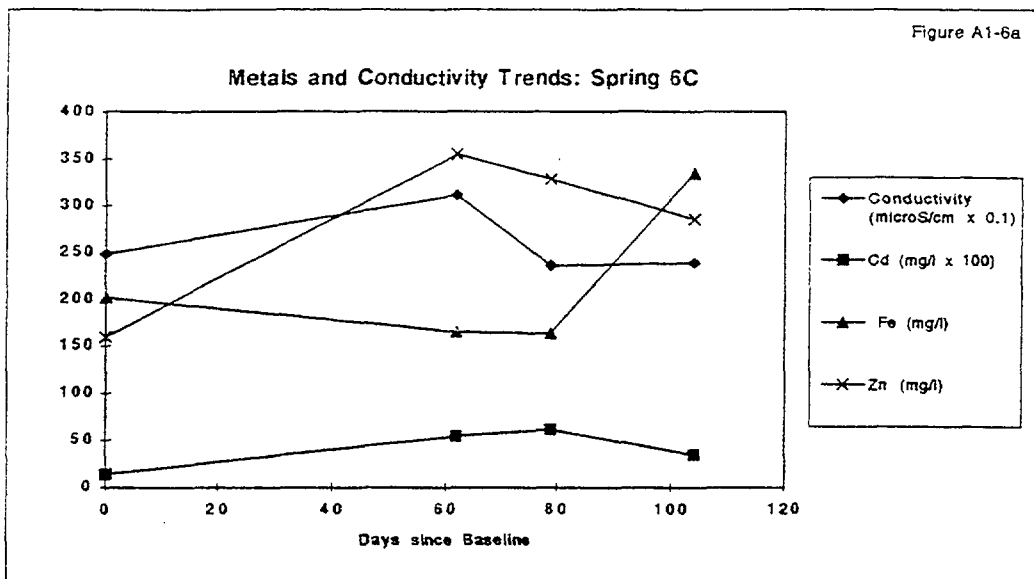


Figure A1-6b

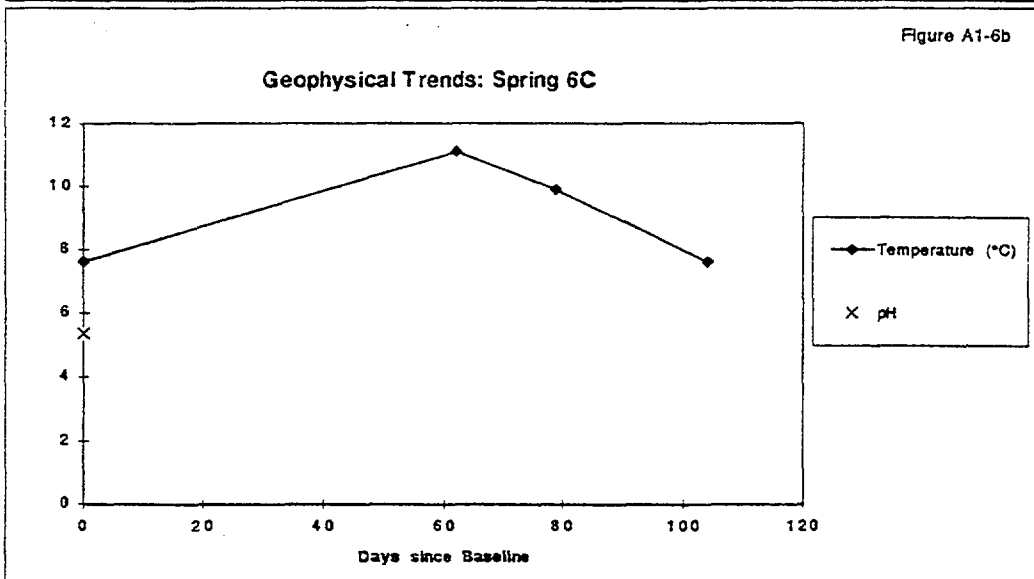
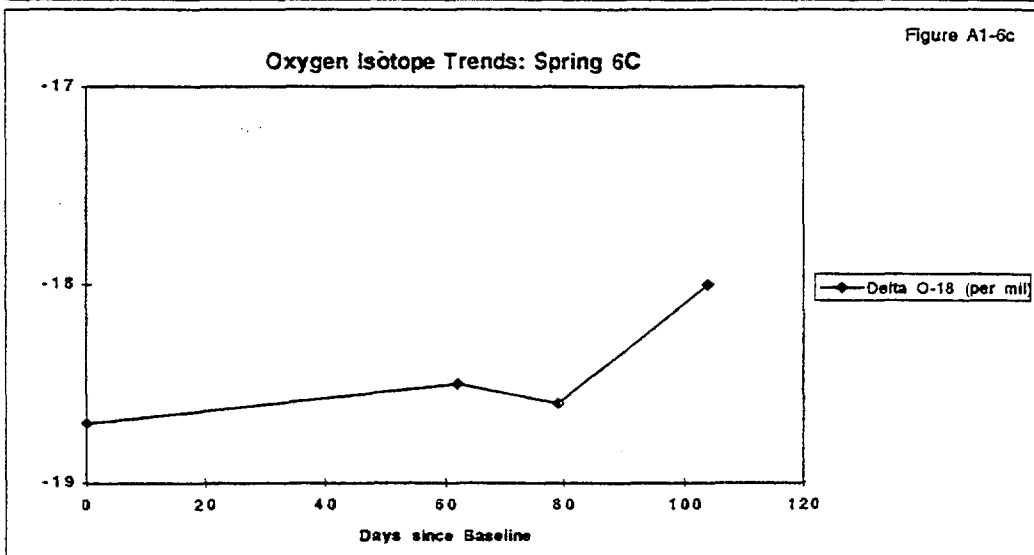


Figure A1-6c



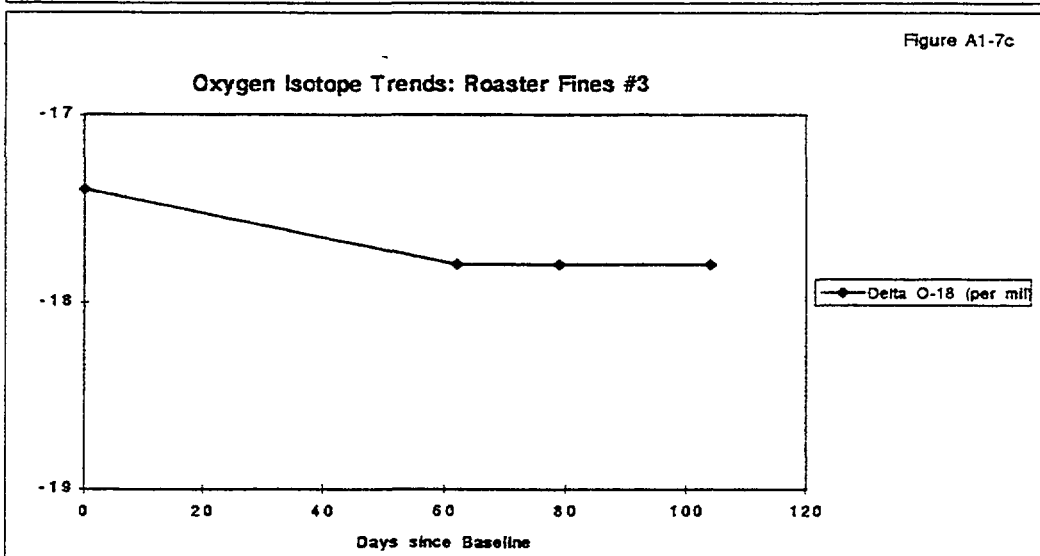
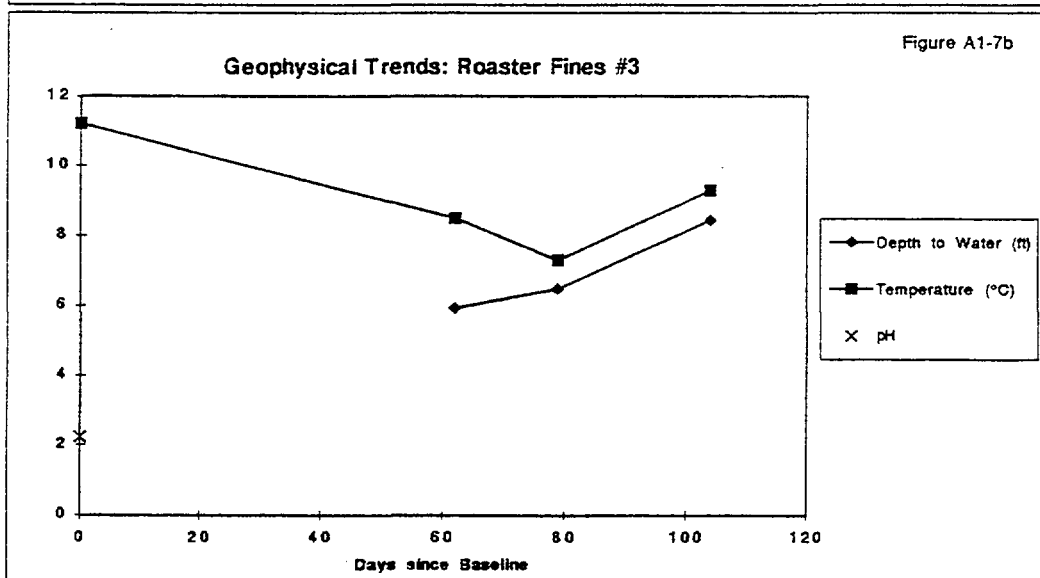
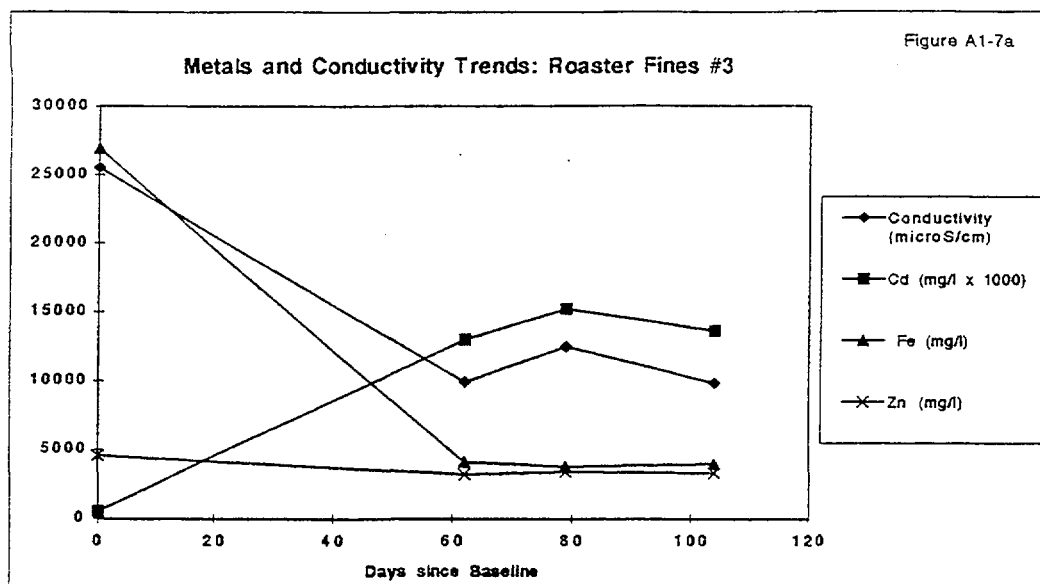
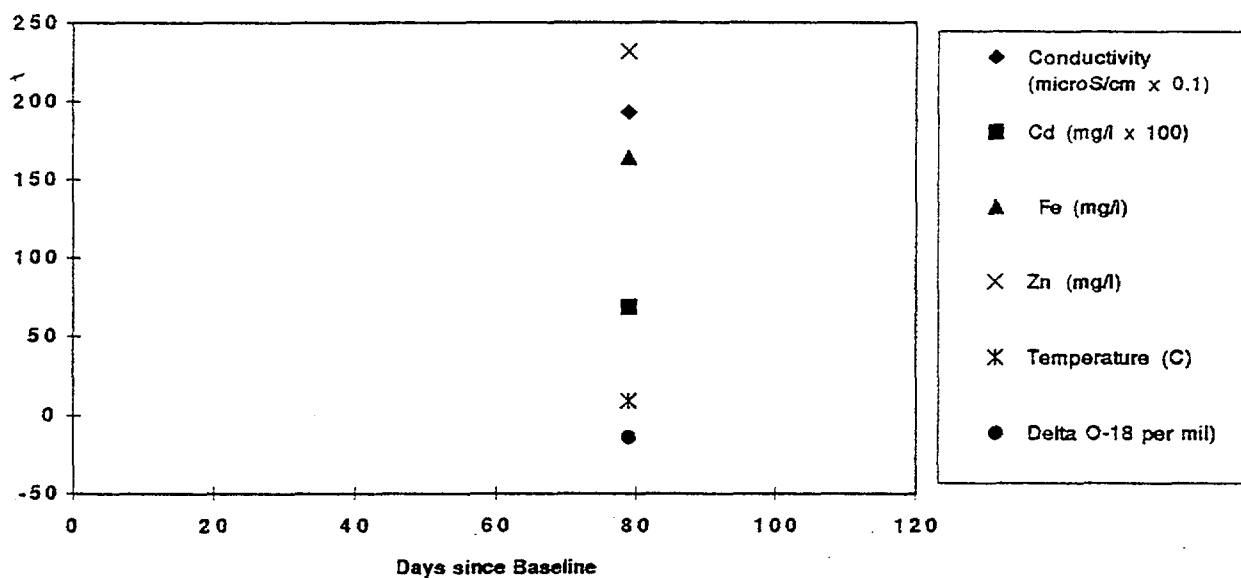
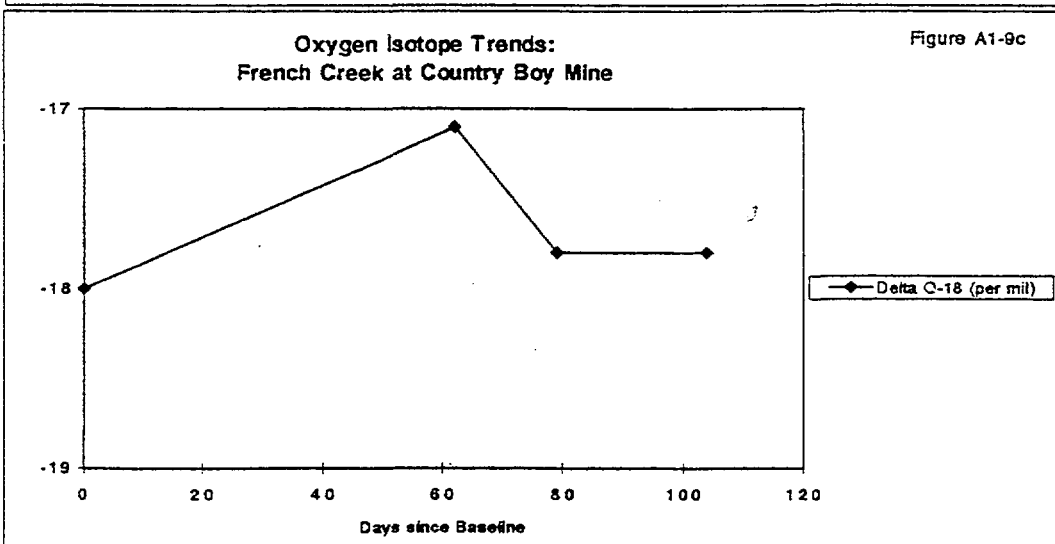
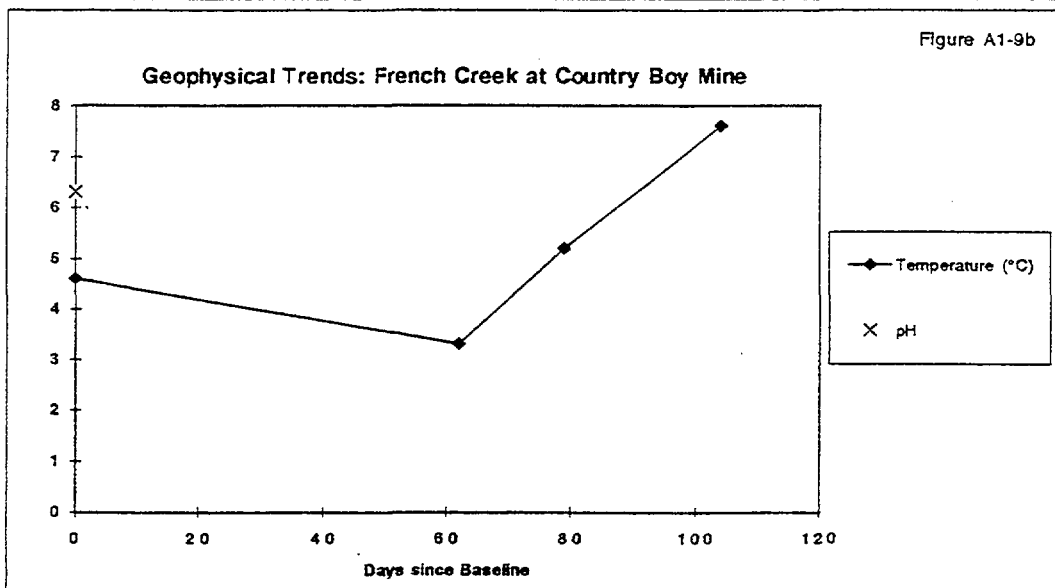
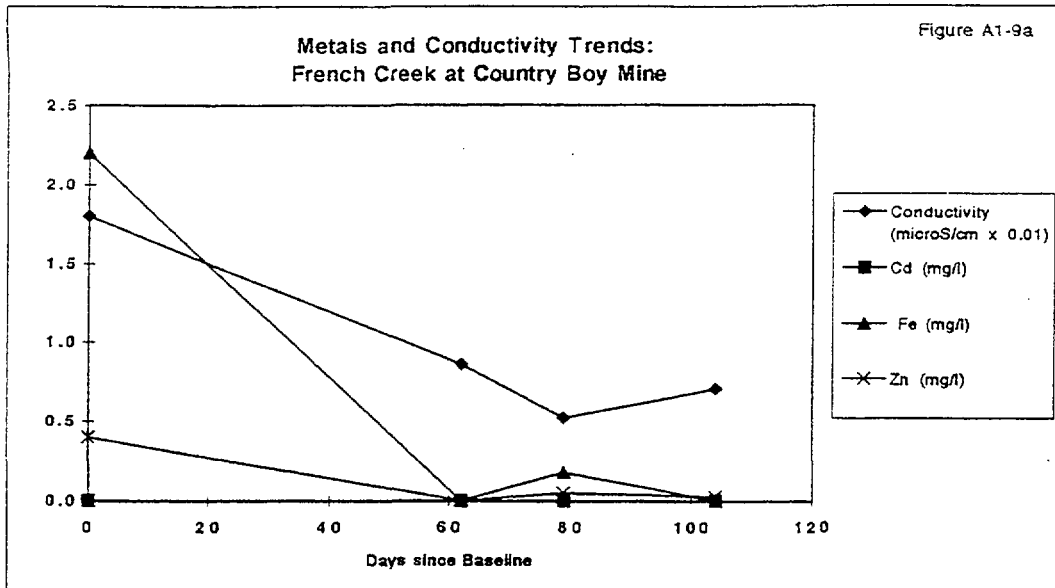


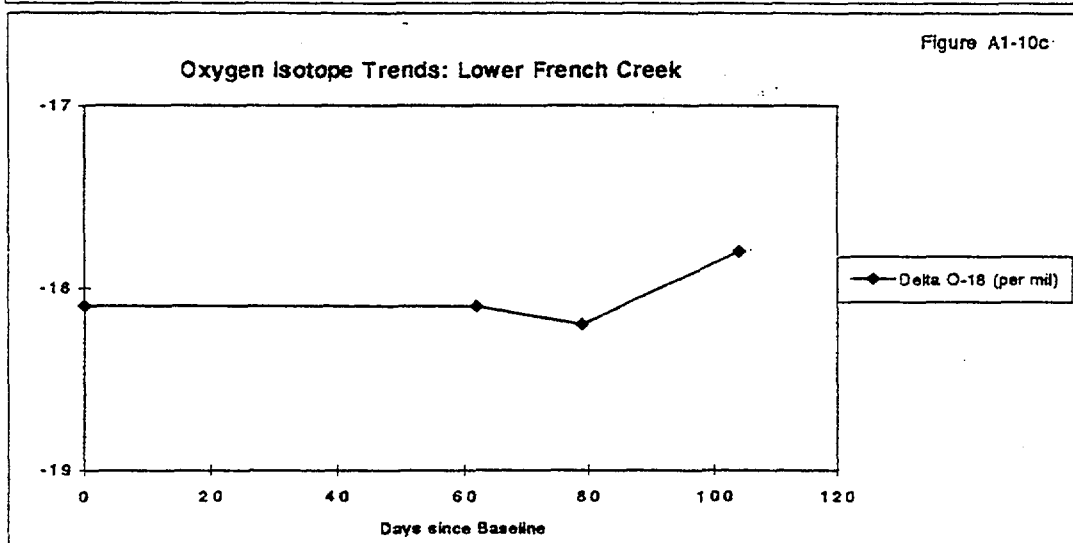
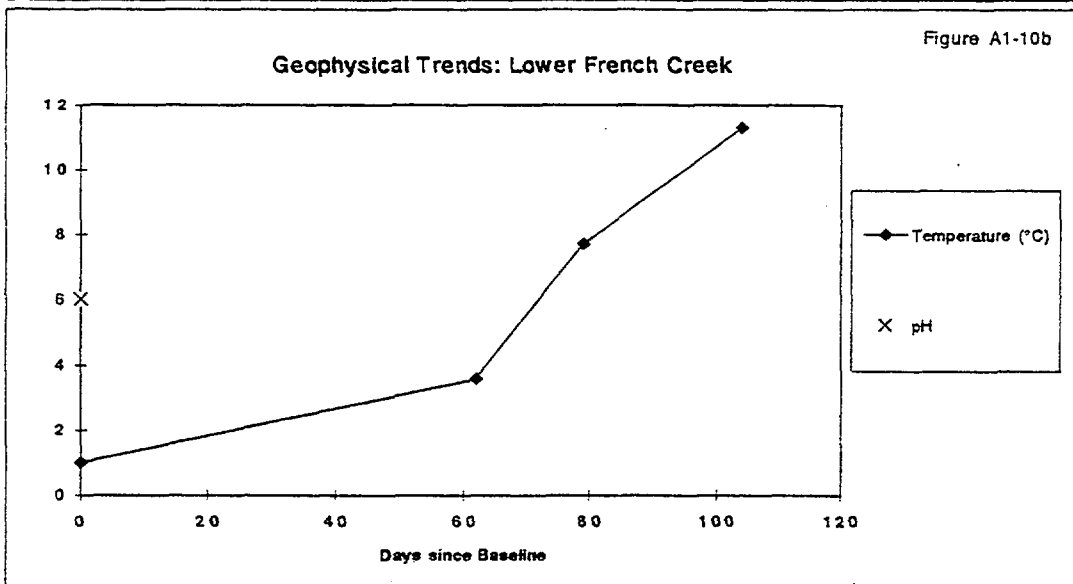
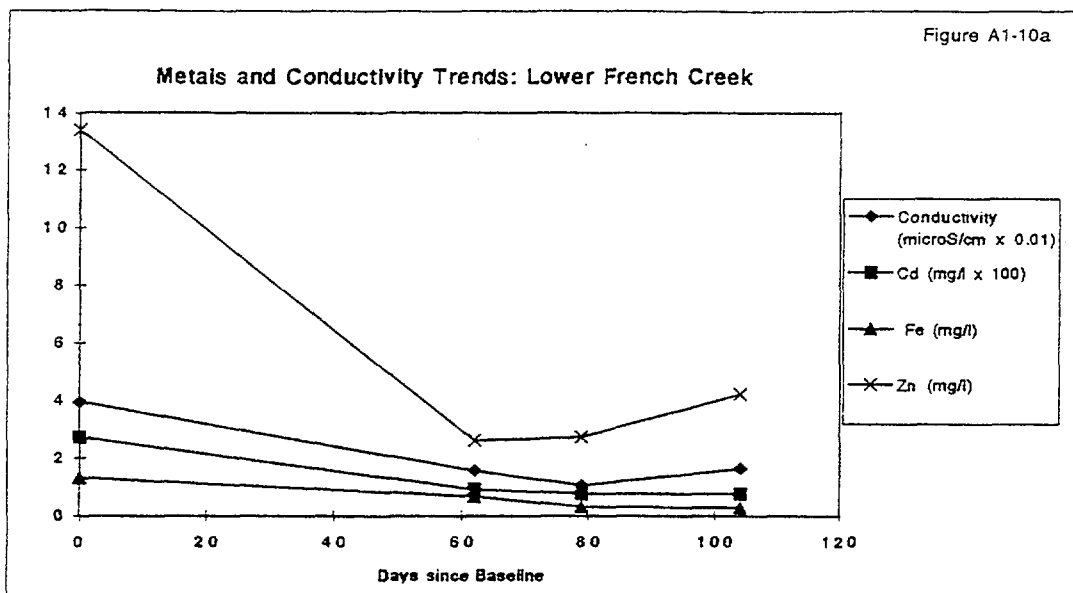


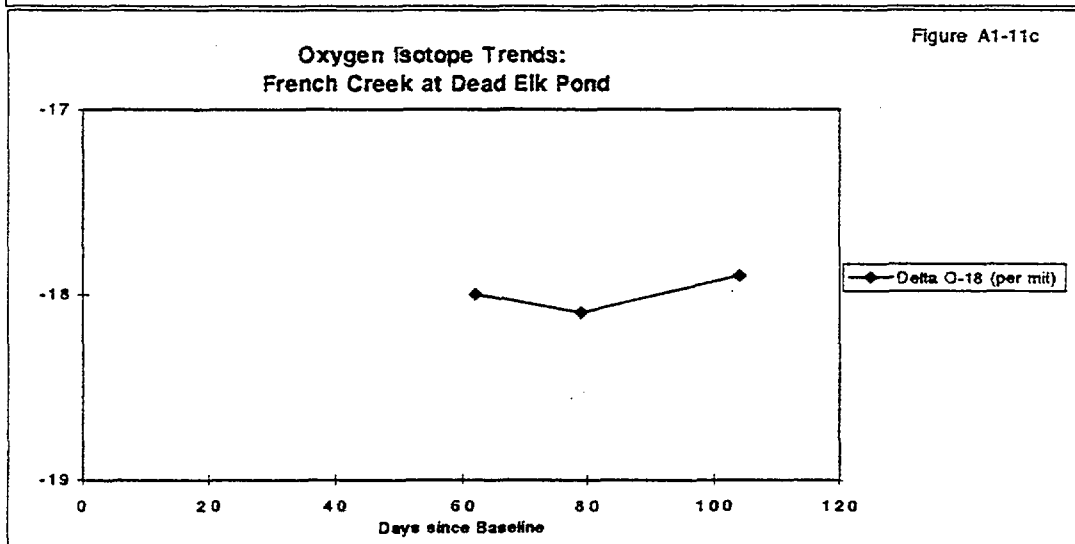
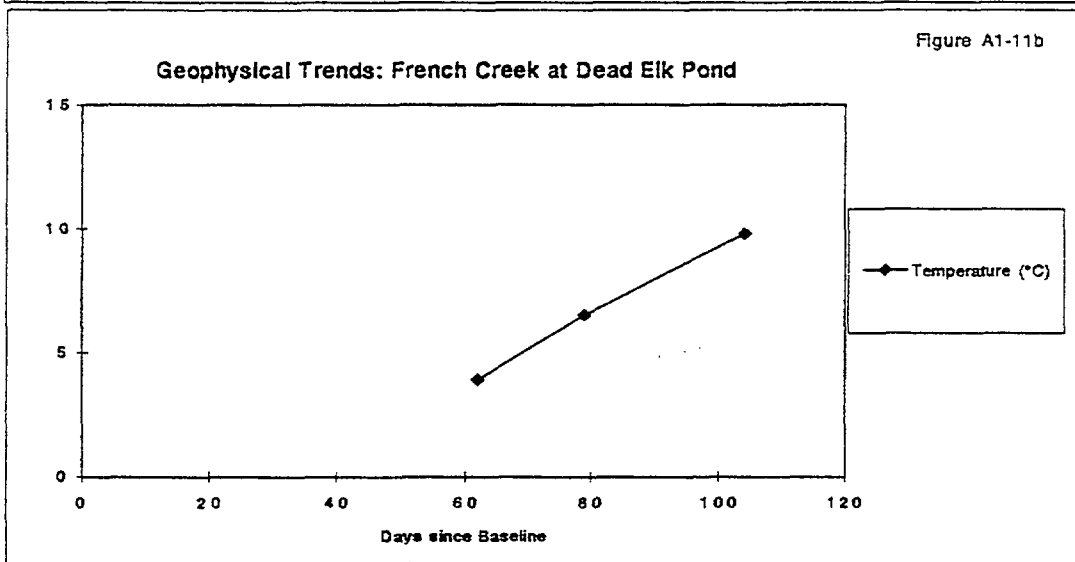
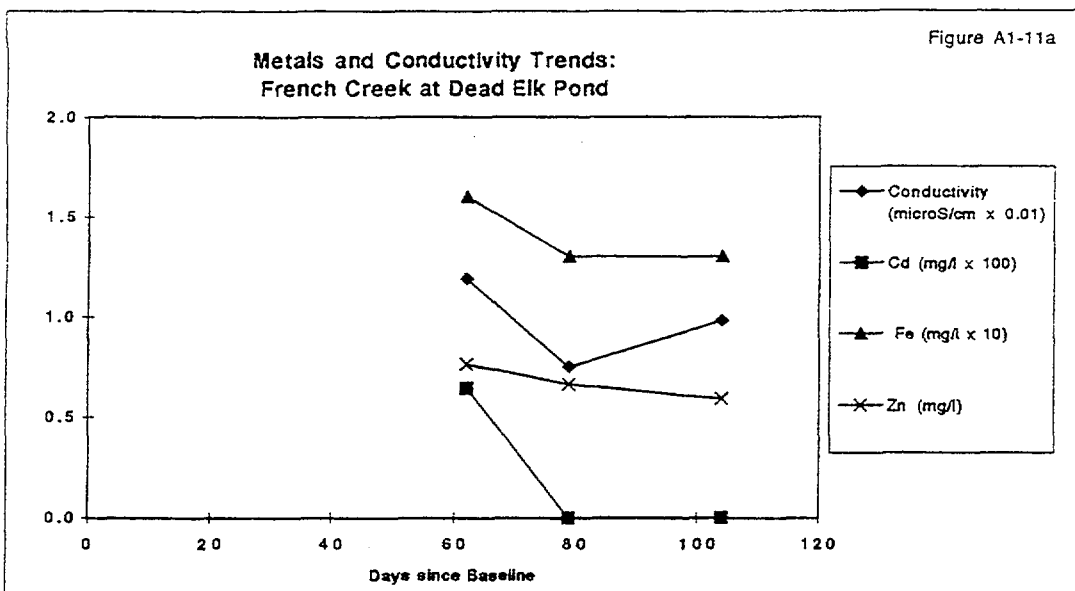
Figure A1-8

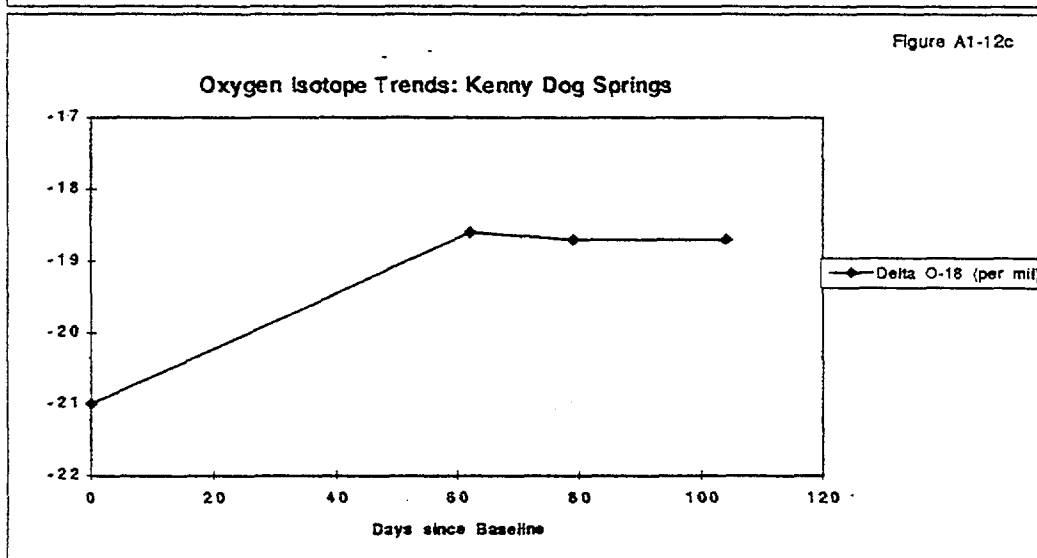
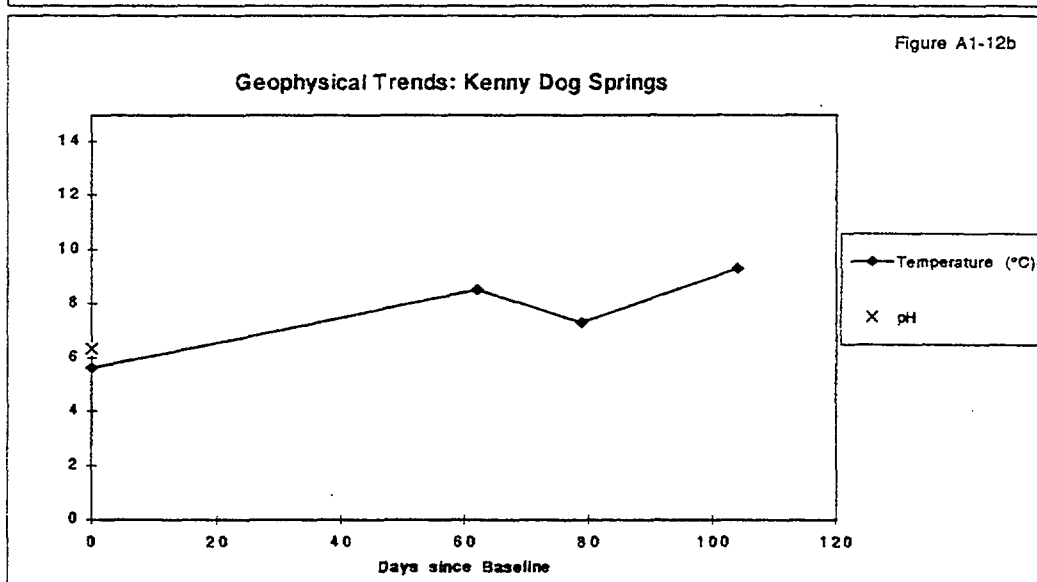
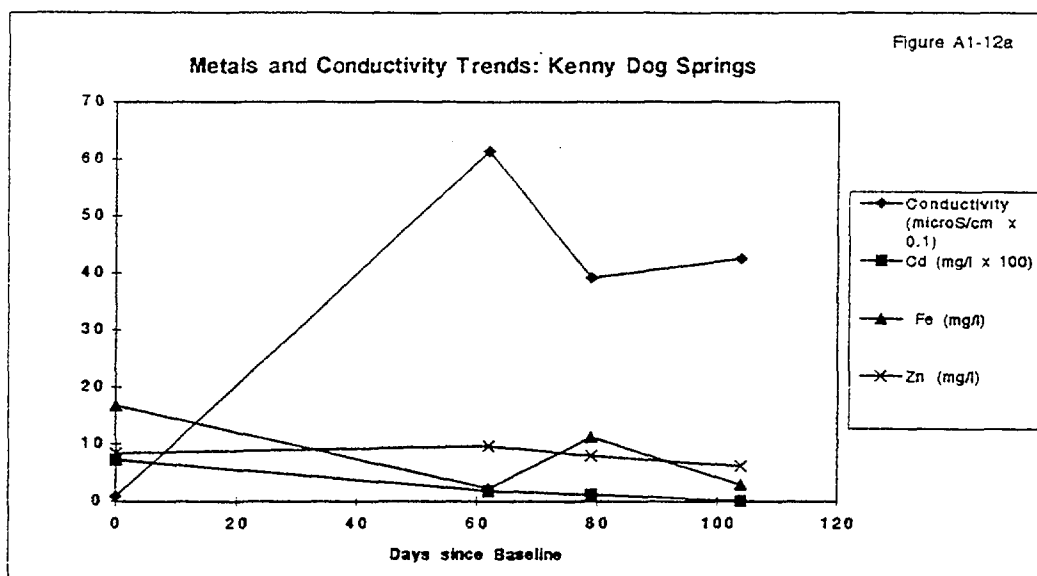
**Geochemical and Geophysical Data: #3 Mine Water  
(Single Sampling)**











## **Appendix 2**

### **Data Reports for Stable Isotope Analyses**

October 10, 1996

**Stable Isotope Analysis Results**

Sample	$\delta D$	$\delta^{18}O$	Sample	$\delta D$	$\delta^{18}O$
FG001	-132	-17.7	FG0024	-142	-18.8
FG002	-131	-18.0	FG0025	-137	-17.8
FG003	-141	-18.9	FG0026	-145	-18.8
FG004	-136	-18.2	FG0027	-144	-18.8
FG005	-141	-18.8	FG0028	-139	-18.6
FG006	-141	-18.7	FG0029	-141	-18.7
FG007	-159	-21.0	FG0030	-146	-18.7
FG008	-133	-17.4	FG0031	-127	-17.8
FG009	-132	-18.0	FG0032	-139	-18.6
FG0010	-206	-27.2	FG0033	-127	-18.2
FG0011	-132	-18.1	FG0034	-127	-18.1
FG0012	-136	-18.0	FG0035	-135	-18.6
FG0013	-134	-18.1	FG0036	-122	-17.4
FG0014	-136	-18.1	FG0037	-131	-18.4
FG0015	-130	-17.8	FG0038	-135	-18.6
FG0016	-143	-18.4	FG0039	-135	-18.7
FG0017	-143	-18.5	FG0040	NA	-17.8
FG0018	-144	-18.6	FG0041	-142	-18.7
FG0019	-144	-18.6	FG0042	-126	-17.8
FG0020	-143	-18.5	FG0043	-136	-18.0
FG0021	-137	-18.1	FG0044	-127	-17.8
FG0022	-136	-18.0	FG0045	-125	-17.9
FG0023	-137	-18.0			

**Duplicate Analyses**

Hydrogen Isotopes				Oxygen Isotopes			
Sample	Duplicate 1	Duplicate 2	SD	Sample	Duplicate 1	Duplicate 2	SD
FG0002	-17.9	-18.1	0.01	FG0001	-129	-135	3
FG0008	-17.4	-17.4	0.04	FG0002	-130	-132	1
FG0009	-18	-18	0.02	FG0022	-134	-138	2
FG0011	-18.1	-18.1	0.01	FG0024	-157	-157	0
Mean SD:			0.02	Mean SD:			1.6

Reviewed by:

  
 Leticia B. Menshaca

## **Appendix 3**

### **Data Reports for Metals Analyses**





Environmental  
Services

Quanterra Environmental Services  
4955 Yarrow Street  
Arvada, CO 80002  
Tel: (303) 421-6611  
Fax: (303) 431-7171

Tel:  
Fax:

REMIT  
TO:

Quanterra, Incorporated  
P.O. Box 91501  
Chicago, IL 606931501

Number

Date

0028115237  
Quanterra Project Number

10 JUL 96  
Customer Number

RMAL-049918  
Terms

00374328

NET 30 DAYS

Customer Contact

Bill To:

Bill Pedler  
R.A.S. Inc.  
311 Rock Avenue  
Golden, CO 80401

Bill Pedler  
R.A.S. Inc.  
311 Rock Avenue  
Golden, CO 80401

Line No.	Qty.	Matrix Code	Analysis Description	Unit Price	Extended Price
1	12	AQUEOUS	ANALYTICAL SERVICES Method 6010 - ICP Metals (Total)	59.00	708.00
			Analytical Services Subtotal	708.00	
			ADDITIONAL SERVICES		
			Additional Services Subtotal	0.00	

Customer P.O. Number / Contract Number / Reference

verbal per Bill Pedler  
Quanterra Program Administrator

Salesperson

Susan McCool  
QUA-4027-B

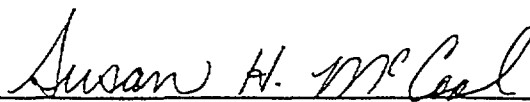
Lisa Davis

Sub Total 708.0  
Tax  
Total 708.0

Federal Tax I.D. # 84

ANALYTICAL RESULTS  
FOR  
R.A.S., Inc.  
FRENCH GULCH WATERSHEAD STUDY  
QUANTERRA ENVIRONMENTAL SERVICES  
DENVER NO. 049918  
JULY 10, 1996

Reviewed by:

  
Susan H. McCool

# Chain of Custody Record



Environmental  
Services

QUA-4124-1

Client <b>RAS, INC.</b>		Project Manager <b>Bill PEDLER</b>		Date <b>6-11-96</b>	Chain Of Custody Number <b>75657</b>
Address <b>311 Rock Ave</b>		Telephone Number (Area Code)/Fax Number <b>803-517-0509</b>		Lab Number <b>047974(?)</b>	Page <b>1</b> of <b>1</b>

City <b>Golden</b>	State <b>CO</b>	Zip Code <b>80401</b>	Site Contact	Lab Contact <b>S. M. COOL</b>	Analysis (Attach list if more space is needed)	Special Instructions/ Conditions of Receipt  <b>H9512</b>
Project Name <b>French Green</b>			Carrier/Waybill Number			

Contract/Purchase Order/Quote No.			Matrix				Containers & Preservatives							CP-TOTAL			Conditions of Receipt																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
Sample I.D. No. and Description (Containers for each sample may be combined on one line)	Date	Time	Aqueous	Sed.	Soil		Unpres.	H2SO4	HNO3	HCl	NaOH	ZnAc	NaOH																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															

MATRIX SPIKE/MATRIX SPIKE DUPLICATE QC REPORT  
Metals Analysis and Preparation  
Project: 049512

Category: ICP-AT ICP Metals / Total  
Matrix: AQUEOUS  
Sample: 049484-0001  
MS Run: 12 JUN 96-N1  
Units: mg/L

Analyte	Sample Result	Concentration		Amount Spiked		% Recovery		Recov. Accep. Limits	RPD MS-MSD	RPD Accep. Limits
		MS Result	MSD Result	MS	MSD	MS	MSD			
Aluminum	ND	2.2	2.2	2.0	2.0	108	110	80-120	1.1	
Antimony	ND	0.47	0.47	0.50	0.50	94	94	80-120	0.7	
Arsenic	ND	1.9	1.9	2.0	2.0	95	95	80-120	0.1	
Barium	ND	2.0	2.0	2.0	2.0	99	100	80-120	0.4	
Beryllium	ND	0.048	0.048	0.050	0.050	97	97	80-120	0.0	
Boron	NA	NA	NA	10	10	NC	NC	80-120	0.0	
Cadmium	ND	0.041	0.048	0.050	0.050	82	96	80-120	16	
Calcium	28	76	77	50	50	96	97	80-120	0.7	
Chromium	NA	NA	NA	0.20	0.20	NC	NC	80-120	0.0	
Cobalt	ND	0.48	0.49	0.50	0.50	97	98	80-120	1.5	
Copper	ND	0.25	0.25	0.25	0.25	100	100	80-120	0.4	
Iron	ND	1.1	1.1	1.0	1.0	107	108	80-120	1.3	
Lead	ND	0.48	0.47	0.50	0.50	97	94	80-120	2.5	
Lithium	NA	NA	NA	5.0	5.0	NC	NC	80-120	0.0	
Magnesium	11	59	60	50	50	97	98	80-120	0.8	
Manganese	ND	0.48	0.49	0.50	0.50	96	97	80-120	1.1	
Molybdenum	ND	NA	NA	0.50	0.50	NC	NC	80-120	0.0	
Nickel	ND	0.48	0.48	0.50	0.50	95	95	80-120	0.0	
Potassium	7.2	56	56	50	50	98	97	80-120	0.5	
Selenium	ND	2.1	2.1	2.0	2.0	105	104	80-120	1.3	
Silver	ND	0.050	0.050	0.050	0.050	100	99	80-120	0.9	
Sodium	120	170	170	50	50	94	96	80-120	0.7	
Thallium	ND	2.2	2.3	2.0	2.0	112	113	80-120	1.4	
Tin	NA	NA	NA	0.50	0.50	NC	NC	80-120	0.0	
Titanium	NA	NA	NA	0.50	0.50	NC	NC	80-120	0.0	
Vanadium	ND	0.50	0.50	0.50	0.50	99	100	80-120	0.6	
Zinc	ND	0.46	0.47	0.50	0.50	93	94	80-120	1.9	

NA = Not Applicable

NC = Not Calculated, calculation not applicable.

ND = Not Detected

Calculations are performed before rounding to avoid round-off errors in calculated results

METHOD BLANK REPORT  
Metals Analysis and Preparation

Analyte	Result	Units	Reporting Limit
Test: ICP-AT			
Matrix: AQUEOUS			
QC Lot: 12 JUN 96-N1 QC Run: 12 JUN 96-N1			
Cadmium	ND	mg/L	0.0050
Iron	ND	mg/L	0.10
Zinc	ND	mg/L	0.051

METHOD BLANK REPORT  
Metals Analysis and Preparation

Analyte	Result	Units	Reporting Limit
Test: ICP-AT			
Matrix: AQUEOUS			
QC Lot: 12 JUN 96-N1 QC Run: 12 JUN 96-N1			
Cadmium	ND	mg/L	0.0050
Iron	ND	mg/L	0.10
Zinc	ND	mg/L	0.051

QC LOT ASSIGNMENT REPORT  
Metals Analysis and Preparation

Laboratory Sample Number	QC Matrix	QC Category	QC Lot Number (DCS)	QC Run Number (SCS/BLANK)
049512-0001-SA	AQUEOUS	ICP-AT	12 JUN 96-N1	12 JUN 96-N1
049512-0002-SA	AQUEOUS	ICP-AT	12 JUN 96-N1	12 JUN 96-N1
049512-0003-SA	AQUEOUS	ICP-AT	12 JUN 96-N1	12 JUN 96-N1
049512-0004-SA	AQUEOUS	ICP-AT	12 JUN 96-N1	12 JUN 96-N1
049512-0005-SA	AQUEOUS	ICP-AT	12 JUN 96-N1	12 JUN 96-N1
049512-0006-SA	AQUEOUS	ICP-AT	12 JUN 96-N1	12 JUN 96-N1
049512-0007-SA	AQUEOUS	ICP-AT	12 JUN 96-N1	12 JUN 96-N1
049512-0008-SA	AQUEOUS	ICP-AT	12 JUN 96-N1	12 JUN 96-N1
049512-0009-SA	AQUEOUS	ICP-AT	12 JUN 96-N1	12 JUN 96-N1
049512-0010-SA	AQUEOUS	ICP-AT	12 JUN 96-N1	12 JUN 96-N1
049512-0011-SA	AQUEOUS	ICP-AT	12 JUN 96-N1	12 JUN 96-N1

Metals

Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0022  
Lab ID: 049512-0011-SA  
Matrix: AQUEOUS  
Authorized: 11 JUN 96

Sampled: 10 JUN 96  
Prepared: See Below

Received: 11 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.0064	mg/L	0.0050	6010	12 JUN 96	19 JUN 96
Iron	0.16	mg/L	0.10	6010	12 JUN 96	19 JUN 96
Zinc	0.76	mg/L	0.051	6010	12 JUN 96	19 JUN 96

ND = Not detected  
NA = Not applicable

Reported By: Patrick Carroll

Approved By: Kristina Sanchez



**Metals****Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0021  
Lab ID: 049512-0010-SA  
Matrix: AQUEOUS  
Authorized: 11 JUN 96

Sampled: 10 JUN 96  
Prepared: See Below

Received: 11 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.0089	mg/L	0.0050	6010	12 JUN 96	19 JUN 96
Iron	0.64	mg/L	0.10	6010	12 JUN 96	19 JUN 96
Zinc	2.6	mg/L	0.051	6010	12 JUN 96	19 JUN 96

ND = Not detected  
NA = Not applicable

Reported By: Patrick Carroll

Approved By: Kristina Sanchez

## Metals

## Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0020  
Lab ID: 049512-0009-SA  
Matrix: AQUEOUS  
Authorized: 11 JUN 96

Sampled: 10 JUN 96  
Prepared: See Below

Received: 11 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.54	mg/L	0.25	6010	12 JUN 96	19 JUN 96
Iron	165	mg/L	5.0	6010	12 JUN 96	19 JUN 96
Zinc	355	mg/L	2.6	6010	12 JUN 96	19 JUN 96

ND = Not detected  
NA = Not applicable

Reported By: Patrick Carroll

Approved By: Kristina Sanchez

**Metals****Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0018  
Lab ID: 049512-0007-SA  
Matrix: AQUEOUS  
Authorized: 11 JUN 96

Sampled: 10 JUN 96  
Prepared: See Below

Received: 11 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.072	mg/L	0.010	6010	12 JUN 96	19 JUN 96
Iron	120	mg/L	0.20	6010	12 JUN 96	19 JUN 96
Zinc	127	mg/L	0.10	6010	12 JUN 96	19 JUN 96

ND = Not detected  
NA = Not applicable

Reported By: Patrick Carroll

Approved By: Kristina Sanchez

**Metals****Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0019  
Lab ID: 049512-0008-SA  
Matrix: AQUEOUS  
Authorized: 11 JUN 96

Sampled: 10 JUN 96  
Prepared: See Below

Received: 11 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.017	mg/L	0.0050	6010	12 JUN 96	19 JUN 96
Iron	2.1	mg/L	0.10	6010	12 JUN 96	19 JUN 96
Zinc	9.6	mg/L	0.051	6010	12 JUN 96	19 JUN 96

ND = Not detected  
NA = Not applicable

Reported By: Patrick Carroll

Approved By: Kristina Sanchez

**Metals****Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0016  
Lab ID: 049512-0005-SA  
Matrix: AQUEOUS  
Authorized: 11 JUN 96

Sampled: 10 JUN 96  
Prepared: See Below

Received: 11 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.34	mg/L	0.025	6010	12 JUN 96	19 JUN 96
Iron	297	mg/L	0.50	6010	12 JUN 96	19 JUN 96
Zinc	277	mg/L	0.26	6010	12 JUN 96	19 JUN 96

ND = Not detected  
NA = Not applicable

Reported By: Patrick Carroll

Approved By: Kristina Sanchez

## Metals

## Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0017  
Lab ID: 049512-0006-SA  
Matrix: AQUEOUS  
Authorized: 11 JUN 96

Sampled: 10 JUN 96  
Prepared: See Below

Received: 11 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.63	mg/L	0.025	6010	12 JUN 96	19 JUN 96
Iron	169	mg/L	0.50	6010	12 JUN 96	19 JUN 96
Zinc	230	mg/L	0.26	6010	12 JUN 96	19 JUN 96

ND = Not detected  
NA = Not applicable

Reported By: Patrick Carroll

Approved By: Kristina Sanchez

**Metals****Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0014  
Lab ID: 049512-0003-SA  
Matrix: AQUEOUS  
Authorized: 11 JUN 96

Sampled: 10 JUN 96  
Prepared: See Below

Received: 11 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	ND	mg/L	0.0050	6010	12 JUN 96	19 JUN 96
Iron	ND	mg/L	0.10	6010	12 JUN 96	19 JUN 96
Zinc	ND	mg/L	0.051	6010	12 JUN 96	19 JUN 96

ND = Not detected  
NA = Not applicable

Reported By: Patrick Carroll

Approved By: Kristina Sanchez

**Metals****Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0015  
Lab ID: 049512-0004-SA  
Matrix: AQUEOUS  
Authorized: 11 JUN 96

Sampled: 10 JUN 96  
Prepared: See Below

Received: 11 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	13.0	mg/L	0.25	6010	12 JUN 96	19 JUN 96
Iron	4090	mg/L	5.0	6010	12 JUN 96	19 JUN 96
Zinc	3160	mg/L	2.6	6010	12 JUN 96	19 JUN 96

ND = Not detected  
NA = Not applicable

Reported By: Patrick Carroll

Approved By: Kristina Sanchez



Metals

Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0012  
Lab ID: 049512-0001-SA  
Matrix: AQUEOUS  
Authorized: 11 JUN 96

Sampled: 10 JUN 96  
Prepared: See Below

Received: 11 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.0054	mg/L	0.0050	6010	12 JUN 96	19 JUN 96
Iron	0.46	mg/L	0.10	6010	12 JUN 96	19 JUN 96
Zinc	0.13	mg/L	0.051	6010	12 JUN 96	19 JUN 96

ND = Not detected  
NA = Not applicable

Reported By: Patrick Carroll

Approved By: Kristina Sanchez

## Metals

## Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0013  
Lab ID: 049512-0002-SA  
Matrix: AQUEOUS  
Authorized: 11 JUN 96

Sampled: 10 JUN 96  
Prepared: See Below

Received: 11 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.010	mg/L	0.0050	6010	12 JUN 96	19 JUN 96
Iron	5.9	mg/L	0.10	6010	12 JUN 96	19 JUN 96
Zinc	1.7	mg/L	0.051	6010	12 JUN 96	19 JUN 96

ND = Not detected  
NA = Not applicable

Reported By: Patrick Carroll

Approved By: Kristina Sanchez

## Analytical Results

The analytical results for this project are presented in the following data tables. Each data table includes sample identification information, and when available and appropriate, dates sampled, received, authorized, prepared and analyzed. The authorization data is the date when the project was defined by the client such that laboratory work could begin.

Data sheets contain a listing of the parameters measured in each test, the analytical results and the Quanterra reporting limit. Reporting limits are adjusted to reflect dilution of the sample, when appropriate.

The results from the Standard Quanterra QA/QC Program, which generates data which are independent of matrix effects, are provided subsequently.

ANALYTICAL TEST REQUESTS  
for  
R.A.S. Inc.

Lab ID: 049512	Group Code	Analysis Description	Custom Test?
0001 - 0011	A	ICP Metals (Total) Prep - Total Metals, ICP	Y N

SAMPLE DESCRIPTION INFORMATION  
for  
R.A.S. Inc.

Lab ID	Client ID	Matrix	Sampled Date	Time	Received Date
049512-0001-SA	FG0012	AQUEOUS	10 JUN 96		11 JUN 96
049512-0002-SA	FG0013	AQUEOUS	10 JUN 96		11 JUN 96
049512-0003-SA	FG0014	AQUEOUS	10 JUN 96		11 JUN 96
049512-0004-SA	FG0015	AQUEOUS	10 JUN 96		11 JUN 96
049512-0005-SA	FG0016	AQUEOUS	10 JUN 96		11 JUN 96
049512-0006-SA	FG0017	AQUEOUS	10 JUN 96		11 JUN 96
049512-0007-SA	FG0018	AQUEOUS	10 JUN 96		11 JUN 96
049512-0008-SA	FG0019	AQUEOUS	10 JUN 96		11 JUN 96
049512-0009-SA	FG0020	AQUEOUS	10 JUN 96		11 JUN 96
049512-0010-SA	FG0021	AQUEOUS	10 JUN 96		11 JUN 96
049512-0011-SA	FG0022	AQUEOUS	10 JUN 96		11 JUN 96

## LIMs Report Key

Section	Description
Cover Letter	Signature page, report narrative as applicable.
Sample Description Information	Tabulated cross-reference between the Lab ID and Client ID, including matrix, date and time sampled, and the date received for all samples in the project.
Sample Analysis Results Sheets	Lists sample results, test components, reporting limits, dates prepared and analyzed, and any data qualifiers. Pages are organized by test.
QC LOT Assignment Report	Cross-reference between lab IDs and applicable QC batches (DCS, LCS, Blank, MS/SD, DU)
Duplicate Control Sample Report	Percent recovery and RPD results, with acceptance limits, for the laboratory duplicate control samples for each test are tabulated in this report. These are measures of accuracy and precision for each test. Acceptance limits are based upon laboratory historical data.
Laboratory Control Sample Report	Percent recovery results for a single Laboratory Control Sample (if applicable) are tabulated in this report, with the applicable acceptance limits for each test.
Matrix Spike/Matrix Spike Duplicate Report	Percent recovery and RPD results for matrix-specific QC samples and acceptance limits, where applicable. This report can be used to assess matrix effects on an analysis.
Single Control Sample Report	A tabulation of the surrogate recoveries for the blank for organic analyses.
Method Blank Report	A summary of the results of the analysis of the method blank for each test.

## List of Abbreviations and Terms

Abbreviation	Term	Abbreviation	Term
DCS	Duplicate Control Sample	MSD	Matrix Spike Duplicate
DU	Sample Duplicate	QC Run	Preparation Batch
EB	Equipment Blank	QC Category	LIMs QC Category
FB	Field Blank	QC Lot	DCS Batch
FD	Field Duplicate	ND	Not Detected at or above the reporting limit expressed
IDL	Instrument Detection Limit (Metals)	QC Matrix	Matrix of the laboratory control sample(s)
LCS	Laboratory Control Sample	RL	Reporting Limit
MB	Method Blank	QC	Quality Control
MDL	Method Detection Limit	SA	Sample
MS	Matrix Spike	SD	Spike Duplicate
RPD	Relative Percent Difference	TB	Trip Blank
ppm (part-per-million)	mg/L or mg/kg (usually)	ppb (part-per-billion)	ug/L or ug/kg (usually)
QUAL	Qualifier flag	DIL	Dilution Factor

## Introduction

This report presents the analytical results as well as supporting information to aid in the evaluation and interpretation of the data and is arranged in the following order:

- o Sample Description Information
- o Analytical Test Requests
- o Analytical Results

All analyses at Quanterra are performed so that the maximum concentration of sample consistent with the method is analyzed. Dilutions are at times required to avoid saturation of the detector, to achieve linearity for a specific target compound, or to reduce matrix interferences. In this event, reporting limits are adjusted proportionately.

All of the zinc reporting limits were raised for all of the samples due to a low level result detected in the instrument blank at the end of the analysis sequence. The blank solutions were remade and the zinc was not detected indicating possible low level contamination. In addition, samples 049512-0004 through -0007, and -0009 were analyzed at dilutions for method 6010 due to the elevated concentration of zinc in the samples. The reporting limits were raised relative to the dilutions required.

## Sample Description Information

The Sample Description Information lists all of the samples received in this project together with the internal laboratory identification number assigned for each sample. Each project received at Quanterra's Denver laboratory is assigned a unique six digit number. Samples within the project are numbered sequentially. The laboratory identification number is a combination of the six digit project code and the sample sequence number.

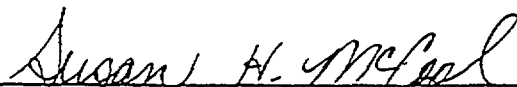
Also given in the Sample Description Information is the Sample Type (matrix), Date of Sampling (if known) and Date of Receipt at the laboratory.

## Analytical Test Requests

The Analytical Test Requests lists the analyses that were performed on each sample. The Custom Test column indicates where tests have been modified to conform to the specific requirements of this project.

ANALYTICAL RESULTS  
FOR  
R.A.S., Inc.  
FRENCH GULCH WATERSHEAD STUDY  
QUANTERRA ENVIRONMENTAL SERVICES  
DENVER NO. 049512  
JUNE 24, 1996

Reviewed by:

  
\_\_\_\_\_  
Susan H. McCool



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## *Standard Deliverable*

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- Sample Description
- Test Requests
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- QC Summary
- Chain-of-Custody
- Miscellaneous

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## Introduction

This report presents the analytical results as well as supporting information to aid in the evaluation and interpretation of the data and is arranged in the following order:

- o Sample Description Information
- o Analytical Test Requests
- o Analytical Results

All analyses at Quanterra are performed so that the maximum concentration of sample consistent with the method is analyzed. Dilutions are at times required to avoid saturation of the detector, to achieve linearity for a specific target compound, or to reduce matrix interferences. In this event, reporting limits are adjusted proportionately.

Samples 049918-0003 through -0006, -0008, and -0010 were analyzed at dilutions for method 6010 due to the elevated concentration of zinc in the samples. The reporting limits were raised relative to the dilutions required.

## Sample Description Information

The Sample Description Information lists all of the samples received in this project together with the internal laboratory identification number assigned for each sample. Each project received at Quanterra's Denver laboratory is assigned a unique six digit number. Samples within the project are numbered sequentially. The laboratory identification number is a combination of the six digit project code and the sample sequence number.

Also given in the Sample Description Information is the Sample Type (matrix), Date of Sampling (if known) and Date of Receipt at the laboratory.

## Analytical Test Requests

The Analytical Test Requests lists the analyses that were performed on each sample. The Custom Test column indicates where tests have been modified to conform to the specific requirements of this project.

## LIMs Report Key

Section	Description
Cover Letter	Signature page, report narrative as applicable.
Sample Description Information	Tabulated cross-reference between the Lab ID and Client ID, including matrix, date and time sampled, and the date received for all samples in the project.
Sample Analysis Results Sheets	Lists sample results, test components, reporting limits, dates prepared and analyzed, and any data qualifiers. Pages are organized by test.
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Single Control Sample Report	A tabulation of the surrogate recoveries for the blank for organic analyses.
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## List of Abbreviations and Terms

Abbreviation	Term	Abbreviation	Term
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DU	Sample Duplicate	QC Run	Preparation Batch
EB	Equipment Blank	QC Category	LIMs QC Category
FB	Field Blank	QC Lot	DCS Batch
FD	Field Duplicate	ND	Not Detected at or above the reporting limit expressed
IDL	Instrument Detection Limit (Metals)	QC Matrix	Matrix of the laboratory control sample(s)
LCS	Laboratory Control Sample	RL	Reporting Limit
MB	Method Blank	QC	Quality Control
MDL	Method Detection Limit	SA	Sample
MS	Matrix Spike	SD	Spike Duplicate
RPD	Relative Percent Difference	TB	Trip Blank
ppm (part-per-million)	mg/L or mg/kg (usually)	ppb (part-per-billion)	ug/L or ug/kg (usually)
QUAL	Qualifier flag	DIL	Dilution Factor

SAMPLE DESCRIPTION INFORMATION  
for  
R.A.S. Inc.

Lab ID	Client ID	Matrix	Sampled Date	Time	Received Date
049918-0001-SA	FG0023	AQUEOUS	27 JUN 96		28 JUN 96
049918-0002-SA	FG0024	AQUEOUS	27 JUN 96		28 JUN 96
049918-0003-SA	FG0025	AQUEOUS	27 JUN 96		28 JUN 96
049918-0004-SA	FG0026	AQUEOUS	27 JUN 96		28 JUN 96
049918-0005-SA	FG0027	AQUEOUS	27 JUN 96		28 JUN 96
049918-0006-SA	FG0028	AQUEOUS	27 JUN 96		28 JUN 96
049918-0007-SA	FG0029	AQUEOUS	27 JUN 96		28 JUN 96
049918-0008-SA	FG0030	AQUEOUS	27 JUN 96		28 JUN 96
049918-0009-SA	FG0031	AQUEOUS	27 JUN 96		28 JUN 96
049918-0010-SA	FG0032	AQUEOUS	27 JUN 96		28 JUN 96
049918-0011-SA	FG0033	AQUEOUS	27 JUN 96		28 JUN 96
049918-0012-SA	FG0034	AQUEOUS	27 JUN 96		28 JUN 96

ANALYTICAL TEST REQUESTS  
for  
R.A.S. Inc.

Lab ID:	Group	Analysis Description	Custom
049918	Code		Test?
0001 - 0012	A	ICP Metals (Total) Prep - Total Metals, ICP	Y N

## Analytical Results

The analytical results for this project are presented in the following data tables. Each data table includes sample identification information, and when available and appropriate, dates sampled, received, authorized, prepared and analyzed. The authorization data is the date when the project was defined by the client such that laboratory work could begin.

Data sheets contain a listing of the parameters measured in each test, the analytical results and the Quanterra reporting limit. Reporting limits are adjusted to reflect dilution of the sample, when appropriate.

The results from the Standard Quanterra QA/QC Program, which generates data which are independent of matrix effects, are provided subsequently.

## Metals

## Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0023  
Lab ID: 049918-0001-SA  
Matrix: AQUEOUS  
Authorized: 28 JUN 96

Sampled: 27 JUN 96  
Prepared: See Below

Received: 28 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	ND	mg/L	0.0050	6010	01 JUL 96	03 JUL 96
Iron	ND	mg/L	0.10	6010	01 JUL 96	03 JUL 96
Zinc	ND	mg/L	0.051	6010	01 JUL 96	03 JUL 96

ND = Not detected  
NA = Not applicable

Reported By: Doug Gomer

Approved By: Richard Persichitte

## Metals

## Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0024  
Lab ID: 049918-0002-SA  
Matrix: AQUEOUS  
Authorized: 28 JUN 96

Sampled: 27 JUN 96  
Prepared: See Below

Received: 28 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.0075	mg/L	0.0050	6010	01 JUL 96	03 JUL 96
Iron	15.7	mg/L	0.10	6010	01 JUL 96	03 JUL 96
Zinc	4.3	mg/L	0.051	6010	01 JUL 96	03 JUL 96

ND = Not detected  
NA = Not applicable

Reported By: Doug Gomer

Approved By: Richard Persichitte



## Metals

## Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0025  
Lab ID: 049918-0003-SA  
Matrix: AQUEOUS  
Authorized: 28 JUN 96

Sampled: 27 JUN 96  
Prepared: See Below

Received: 28 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical - Method	Prepared Date	Analyzed Date
Cadmium	15.2	mg/L	0.25	6010	01 JUL 96	03 JUL 96
Iron	3750	mg/L	5.0	6010	01 JUL 96	03 JUL 96
Zinc	3360	mg/L	2.5	6010	01 JUL 96	03 JUL 96

ND = Not detected  
NA = Not applicable

Reported By: Doug Gomer

Approved By: Richard Persichitte

## Metals

## Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0026  
Lab ID: 049918-0004-SA  
Matrix: AQUEOUS  
Authorized: 28 JUN 96

Sampled: 27 JUN 96  
Prepared: See Below

Received: 28 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.092	mg/L	0.010	6010	01 JUL 96	03 JUL 96
Iron	117	mg/L	0.20	6010	01 JUL 96	03 JUL 96
Zinc	124	mg/L	0.10	6010	01 JUL 96	03 JUL 96

ND = Not detected  
NA = Not applicable

Reported By: Doug Gomer

Approved By: Richard Persichitte

Metals

Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0027  
Lab ID: 049918-0005-SA  
Matrix: AQUEOUS  
Authorized: 28 JUN 96

Sampled: 27 JUN 96  
Prepared: See Below  
Received: 28 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.72	mg/L	0.025	6010	01 JUL 96	03 JUL 96
Iron	184	mg/L	0.50	6010	01 JUL 96	03 JUL 96
Zinc	242	mg/L	0.25	6010	01 JUL 96	03 JUL 96

ND = Not detected  
NA = Not applicable

Reported By: Doug Gomer

Approved By: Richard Persichitte

Metals

Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0028  
Lab ID: 049918-0006-SA  
Matrix: AQUEOUS  
Authorized: 28 JUN 96

Sampled: 27 JUN 96  
Prepared: See Below

Received: 28 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.31	mg/L	0.025	6010	01 JUL 96	03 JUL 96
Iron	279	mg/L	0.50	6010	01 JUL 96	03 JUL 96
Zinc	256	mg/L	0.25	6010	01 JUL 96	03 JUL 96

ND = Not detected  
NA = Not applicable

Reported By: Doug Gomer

Approved By: Richard Persichitte

## Metals

## Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0029  
Lab ID: 049918-0007-SA  
Matrix: AQUEOUS  
Authorized: 28 JUN 96

Sampled: 27 JUN 96  
Prepared: See Below

Received: 28 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.011	mg/L	0.0050	6010	01 JUL 96	03 JUL 96
Iron	11.2	mg/L	0.10	6010	01 JUL 96	03 JUL 96
Zinc	7.9	mg/L	0.051	6010	01 JUL 96	03 JUL 96

ND = Not detected  
NA = Not applicable

Reported By: Doug Gomer

Approved By: Richard Persichitte

## Metals

## Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0030  
Lab ID: 049918-0008-SA  
Matrix: AQUEOUS  
Authorized: 28 JUN 96

Sampled: 27 JUN 96  
Prepared: See Below

Received: 28 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.68	mg/L	0.025	6010	01 JUL 96	03 JUL 96
Iron	164	mg/L	0.50	6010	01 JUL 96	03 JUL 96
Zinc	232	mg/L	0.25	6010	01 JUL 96	03 JUL 96

ND = Not detected  
NA = Not applicable

Reported By: Doug Gomer

Approved By: Richard Persichitte

Metals

Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0031  
Lab ID: 049918-0009-SA  
Matrix: AQUEOUS  
Authorized: 28 JUN 96

Sampled: 27 JUN 96  
Prepared: See Below

Received: 28 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	ND	mg/L	0.0050	6010	01 JUL 96	03 JUL 96
Iron	0.18	mg/L	0.10	6010	01 JUL 96	03 JUL 96
Zinc	<del>ND</del>	mg/L	<del>0.051</del>	6010	01 JUL 96	03 JUL 96

0.048

0.020 ±  
\* REVISED BY LAB  
7-31-96  
WHP

ND = Not detected  
NA = Not applicable

Reported By: Doug Gomer

Approved By: Richard Persichitte

## Metals

## Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0032  
Lab ID: 049918-0010-SA  
Matrix: AQUEOUS  
Authorized: 28 JUN 96

Sampled: 27 JUN 96  
Prepared: See Below

Received: 28 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.61	mg/L	0.025	6010	01 JUL 96	03 JUL 96
Iron	163	mg/L	0.50	6010	01 JUL 96	03 JUL 96
Zinc	328	mg/L	0.25	6010	01 JUL 96	03 JUL 96

ND = Not detected  
NA = Not applicable

Reported By: Doug Gomer

Approved By: Richard Persichitte



## Metals

## Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0033  
Lab ID: 049918-0011-SA  
Matrix: AQUEOUS  
Authorized: 28 JUN 96

Sampled: 27 JUN 96  
Prepared: See Below

Received: 28 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.0074	mg/L	0.0050	6010	01 JUL 96	03 JUL 96
Iron	0.28	mg/L	0.10	6010	01 JUL 96	03 JUL 96
Zinc	2.7	mg/L	0.051	6010	01 JUL 96	03 JUL 96

ND = Not detected  
NA = Not applicable

Reported By: Doug Gomer

Approved By: Richard Persichitte

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0034  
Lab ID: 049918-0012-SA  
Matrix: AQUEOUS  
Authorized: 28 JUN 96

Sampled: 27 JUN 96  
Prepared: See Below

Received: 28 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	ND	mg/L	0.0050	6010	01 JUL 96	03 JUL 96
Iron	0.13	mg/L	0.10	6010	01 JUL 96	03 JUL 96
Zinc	0.66	mg/L	0.051	6010	01 JUL 96	03 JUL 96

ND = Not detected  
NA = Not applicable

Reported By: Doug Gomer

Approved By: Richard Persichitte

QC LOT ASSIGNMENT REPORT  
Metals Analysis and Preparation

Laboratory Sample Number	QC Matrix	QC Category	QC Lot Number (DCS)	QC Run Number (SCS/BLANK)
049918-0001-SA	AQUEOUS	ICP-AT	01 JUL 96-MM	01 JUL 96-MM
049918-0002-SA	AQUEOUS	ICP-AT	01 JUL 96-MM	01 JUL 96-MM
049918-0003-SA	AQUEOUS	ICP-AT	01 JUL 96-MM	01 JUL 96-MM
049918-0004-SA	AQUEOUS	ICP-AT	01 JUL 96-MM	01 JUL 96-MM
049918-0005-SA	AQUEOUS	ICP-AT	01 JUL 96-MM	01 JUL 96-MM
049918-0006-SA	AQUEOUS	ICP-AT	01 JUL 96-MM	01 JUL 96-MM
049918-0007-SA	AQUEOUS	ICP-AT	01 JUL 96-MM	01 JUL 96-MM
049918-0008-SA	AQUEOUS	ICP-AT	01 JUL 96-MM	01 JUL 96-MM
049918-0009-SA	AQUEOUS	ICP-AT	01 JUL 96-MM	01 JUL 96-MM
049918-0010-SA	AQUEOUS	ICP-AT	01 JUL 96-MM	01 JUL 96-MM
049918-0011-SA	AQUEOUS	ICP-AT	01 JUL 96-MM	01 JUL 96-MM
049918-0012-SA	AQUEOUS	ICP-AT	01 JUL 96-MM	01 JUL 96-MM

LABORATORY CONTROL SAMPLE REPORT  
Metals Analysis and Preparation

Analyte	Concentration		Accuracy(%)	
	Spiked	Measured	LCS	Limits
Category: ICP-AT				
Matrix: AQUEOUS				
QC Lot: 01 JUL 96-MM      QC Run: 01 JUL 96-MM				
Concentration Units: mg/L				
Aluminum	2.00	2.08	104	80-116
Antimony	0.500	0.489	98	80-115
Arsenic	2.00	2.00	100	80-115
Barium	2.00	2.01	100	80-114
Beryllium	0.0500	0.0503	101	80-120
Boron	1.00	1.04	104	80-120
Cadmium	0.500	0.493	99	80-119
Calcium	50.0	51.8	104	80-114
Chromium	0.200	0.188	94	80-116
Cobalt	0.500	0.504	101	80-114
Copper	0.250	0.251	100	80-120
Iron	1.00	1.03	103	80-120
Lead	0.500	0.488	98	80-119
Lithium	1.00	0.881	88	80-120
Magnesium	50.0	51.8	104	81-120
Manganese	0.500	0.502	100	80-116
Molybdenum	1.00	0.960	96	80-120
Nickel	0.500	0.495	99	80-114
Potassium	50.0	51.0	102	80-120
Selenium	2.00	2.03	102	80-120
Silver	0.0500	0.0517	103	80-119
Sodium	50.0	52.8	106	80-120
Tin	2.00	1.83	92	80-120
Titanium	1.00	0.954	95	80-120
Vanadium	0.500	0.499	100	80-116
Zinc	0.500	0.491	98	80-120

Calculations are performed before rounding to avoid round-off errors in calculated results

METHOD BLANK REPORT  
Metals Analysis and Preparation

Analyte	Result	Units	Reporting Limit
Test: ICP-AT			
Matrix: AQUEOUS			
QC Lot: 01 JUL 96-MM QC Run: 01 JUL 96-MM			
Cadmium	ND	mg/L	0.0050
Iron	ND	mg/L	0.10
Zinc	ND	mg/L	0.051

MATRIX SPIKE/MATRIX SPIKE DUPLICATE QC REPORT  
Metals Analysis and Preparation  
Project: 049918

Category: ICP-AT ICP Metals / Total  
Matrix: AQUEOUS  
Sample: 049918-0012  
MS Run: 01 JUL 96-MM  
Units: mg/L

Analyte	Sample Result	Concentration		Amount Spiked		% Recovery		Recov. Accep. Limits	RPD MS-MSD	RPD Accep. Limit
		MS Result	MSD Result	MS	MSD	MS	MSD			
Aluminum	0.064	2.1	2.1	2.0	2.0	104	103	80-120	1.0	
Antimony	NA	NA	NA	0.50	0.50	NC	NC	80-120	0.0	
Arsenic	NA	NA	NA	0.50	0.50	NC	NC	80-120	0.0	
Barium	0.010	2.0	2.0	2.0	2.0	98	98	80-120	0.0	
Beryllium	ND	0.050	0.050	0.050	0.050	101	100	80-120	0.9	
Boron	NA	NA	NA	10	10	NC	NC	80-120	0.0	
Cadmium	ND	0.047	0.051	0.050	0.050	95	103	80-120	8.3	
Calcium	18	69	69	50	50	101	100	80-120	0.3	
Chromium	ND	0.18	0.19	0.20	0.20	91	93	80-120	1.7	
Cobalt	ND	0.49	0.49	0.50	0.50	98	98	80-120	0.6	
Copper	ND	0.25	0.25	0.25	0.25	101	100	80-120	0.5	
Iron	0.13	1.1	1.1	1.0	1.0	101	99	80-120	1.9	
Lead	NA	NA	NA	0.50	0.50	NC	NC	80-120	0.0	
Lithium	NA	NA	NA	5.0	5.0	NC	NC	80-120	0.0	
Magnesium	2.2	52	53	50	50	101	101	80-120	0.2	
Manganese	0.066	0.54	0.55	0.50	0.50	95	96	80-120	0.8	
Molybdenum	ND	0.94	0.94	1.0	0.50	94	189	80-120	0.5	
Nickel	ND	0.48	0.48	0.50	0.50	95	97	80-120	1.9	
Potassium	ND	51	51	50	50	103	102	80-120	0.7	
Selenium	NA	NA	NA	0.50	0.50	NC	NC	80-120	0.0	
Silver	ND	0.050	0.051	0.050	0.050	100	102	80-120	2.0	
Sodium	ND	53	54	50	50	107	108	80-120	1.2	
Thallium	NA	NA	NA	5.0	5.0	NC	NC	80-120	0.0	
Tin	NA	NA	NA	0.50	0.50	NC	NC	80-120	0.0	
Titanium	NA	NA	NA	0.50	0.50	NC	NC	80-120	0.0	
Vanadium	ND	0.49	0.49	0.50	0.50	98	97	80-120	0.8	
Zinc	0.66	1.1	1.1	0.50	0.50	90	91	80-120	0.4	

NA = Not Applicable  
NC = Not Calculated, calculation not applicable.  
ND = Not Detected

Calculations are performed before rounding to avoid round-off errors in calculated results.



RADON ABATEMENT SYSTEMS, INC.

Stable Isotopic Investigation of 1996 and 1997  
Snowmelt Events in French Gulch, Colorado

Final Report

Prepared for

Colorado Department of Minerals and Geology

by

Radon Abatement Systems, Inc.  
Golden, Colorado

October 30, 1997



## Executive Summary

In early 1996, Radon Abatement Systems, Inc.(RAS)<sup>1</sup> was contracted by the State of Colorado's Division of Minerals and Geology to evaluate the application of stable isotope hydrology at the French Gulch Site. The objective of this testing was to help delineate the source(s) of metal loading to French Creek. Based on the favorable results of the initial feasibility study (Phase I) additional sampling was contracted (Phases II and III). Over the period from March 1996 to June 1997, five sampling rounds were conducted and 93 total samples were collected. The water samples collected were evaluated for oxygen and hydrogen isotopic signature. Total zinc, cadmium and iron and basic inorganic parameters (pH, fluid electrical conductivity, and temperature) for each sample were also collected. The samples included groundwater, creek/surface water and snow/precipitation samples. Please refer to Attachment I for the detailed final report of this isotope study. This report was prepared for RAS Inc., by Isotope Solutions, Inc. of Berkeley, California.

In addition to the isotope evaluation, RAS performed additional characterization services at French Gulch. This work was separately contracted by URS, a USEPA contractor (RAS, 1997)<sup>2</sup>. This work was predicated by the conclusions of Phase II of the isotope study. The objective of this work was to further delineate the role of the mine pool to the metal flux at French Creek. This work was conducted during low flow conditions and included: 1) ambient flow evaluation in several monitoring wells near the portal of the mine; and, 2) water quality logging (pH, Eh, FEC and temperature), discrete point fluid sampling, video inspection and flow logging of the Oro shaft.

Investigation of the Oro shaft was performed during low flow conditions and was limited by obstructions to the upper half of the shaft. As such, only the upper ~300 feet of the shaft could be evaluated. Vertical flow analysis was performed at four locations corresponding to the depths of the 1<sup>st</sup> through 3<sup>rd</sup> levels and at 288 feet (between the 3<sup>rd</sup> and 4<sup>th</sup> level). The results of the flow logging indicate that no measurable vertical flow was occurring within this interval. Depth specific water samples were collected at 116, 186, 245 and 285 feet. These sampling depths correspond with those depths at which the flow analysis was performed. The depth specific samples were analyzed for total recoverable metals, dissolved metals, chloride, sulfates, total suspended solids, alkalinity, O/D isotopic signature. The results of this investigation indicated that the upper portion of the mine pool at the Oro shaft is reasonably stagnant and has a slightly different isotopic and water quality signature than other observed mine pool water. As such, these data suggest that the upper portion of the mine pool is stagnant and not

<sup>1</sup> RAS is a group of engineers and scientists who's primary goal is the development of an in-situ methodology to remove radionuclides from groundwater. As part of this research, RAS' team includes specialists in the use of natural isotopes to evaluate source water and well capture zones.

<sup>2</sup> Radon Abatement Systems Inc., 1997. Geophysical Logging, Water Quality Evaluation and Stable Isotope Study of the Oro Shaft and Selected Monitoring Wells at the Wellington-Oro Mine Complex, French Gulch, Colorado - Phase I Report- Low Flow Conditions, February, 30 pp.





RADON ABATEMENT SYSTEMS, INC.

contributing to discharge at the fault block. The flow logging conducted near the portal area of the mine further delineates the flow path from the mine to the alluvium aquifer. Upflow was observed in all but one the wells tested in the fault block area between the 1110 and Bullhide faults. Wells tested up gradient of the fault block did not display such strong upflow. From these results, it is reasonable to conclude that the fault block system and mine workings in the fault block system provide the dominant pathway for metal contaminated mine pool waters to reach the alluvium aquifer, and subsequently, French Creek.

The results of the isotope study clearly indicate that waters associated with the mine pool are directly responsible for a majority of the metal loading at French Creek. These results also suggest that a minor proportion of the metal loading is associated with the mine tailings and roaster fines (5-20%). The results of the isotope study suggest a hydrologic model where seasonal snow melt infiltrates into the shallow alluvial aquifer up gradient of the mine pool. At peak flow conditions, during spring run-off, the hydraulic pressure associated with infiltration drives existing groundwater into both the mine pool and the creek. This increased hydraulic pressure then drives water from the mine pool into the shallow alluvium and from the shallow alluvium to French Creek. The stable isotope and flow logging indicate that the fault block area between the 11-10 and Bullhide faults is the area where outflow from the mine is reaching French Creek. The results of the isotope study also suggest that metal loading from the roaster fine and mill tailings is associated primarily with up welling ground water and not surface infiltration. The following is a summary of the conclusions derived from the isotope investigation:

- 1) Three distinct stable isotopic groupings were observed.
- 2) Snowmelt contributed only a small proportion of the water responsible for increased flow in French Creek during the period of sampling.
- 3) The bulk of the water flowing in French Creek during crest periods had an oxygen isotopic composition comparable to that of local groundwater and springs.
- 4) Significant inflow of groundwater to French Creek occurs between the 11-10 and Bullhide faults.
- 5) Increased surface water metal loading occurred during the snowmelt events.
- 6) Surface water infiltration was observed in wells MW-3 and MW-14. Surface water infiltration was not observed in well MW-9, MW-16 and #3 relief well.



RADON ABATEMENT SYSTEMS, INC.

Attachment I

**Stable Isotopic Investigation of 1996 and 1997  
Snowmelt Events in French Gulch, Colorado**

**Final Report**

**Prepared by  
Isotope Solutions  
for  
Radon Abatement Systems, Inc.**

**October 24, 1997**

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# **Stable Isotopic Investigation of 1996 and 1997 Snowmelt Events in French Gulch, Colorado**

## **Final Report**

### Introduction

When rain or snowmelt interacts with sulfide-bearing rocks, oxidation of sulfide minerals can produce acid solutions charged with heavy metals that may be toxic to organisms living in nearby streams and other surface water bodies. In many mining areas in the Western US, well developed low-temperature sulfate alteration attests to interactions between groundwaters and sulfide-bearing rocks producing acid solutions for tens or hundreds of thousands of years or more. In cases such as these, the huge scale of the "toxic runoff" phenomenon may limit remediation strategies to those focusing on fluid management and water treatment. Mining companies should be held accountable for environmental problems that arise from natural processes (such as groundwater interactions with naturally occurring sulfide-bearing rocks) only to the degree that mining activities have exacerbated the situation.

In other mining areas, "toxic runoff" may be caused by rain or snowmelt interacting with surface debris such as mine tailings or overburden piles that have been exposed to surface waters directly through mining activities. This type of "toxic runoff" is likely to be of smaller scale than the natural groundwater/host rock interactions described above and effective remedial designs might include engineering approaches, such as capping and surface water diversion. It is easier to argue that mining companies should be held accountable for environmental problems when mining activities can be demonstrated to cause "toxic runoff". In mining areas affected by "toxic runoff", therefore, it is important to distinguish between "natural" processes and problems caused by mining activities.

This investigation was designed to resolve the roles of groundwater and surface waters in "toxic runoff" events associated with the major 1996 and 1997 Spring snowmelts in the French Gulch historic mining area, near Breckinridge, Colorado. The field investigation was conducted in three phases. Phase I sampling was conducted on March 20, 1996, prior to the beginning of the Spring melting event to provide baseline stable isotopic and geochemical information on groundwaters and surface waters (springs, creeks, snowpack) in the area. A Phase II investigation was implemented based on the very high likelihood of success implied by the Phase I data.

In Phase II, groundwaters and surface waters from twelve sites were sampled three times during the snowmelt event of the Summer of 1996. Water samples were analyzed for oxygen and hydrogen isotopic composition, and for Cadmium, Iron, and Zinc concentration. Field measurements included depth to groundwater, water temperature, and electrical conductivity.

Phase III consisted of two sampling events in the Winter and Spring of 1997, along with a few analyses of mine waters to investigate any systematic differences between the two stable isotope contract laboratories used in this investigation. In Phase III, 7 new groundwater and 7 new surface water sampling locations were added to provide additional coverage. As with Phase II, water samples were analyzed for oxygen and hydrogen isotopic composition, as well as Cadmium, Iron, and Zinc concentration. As before, field measurements included depth to groundwater, water temperature, and electrical conductivity.

10/24/97



## Isotope Solutions

### Analytical Methods and Notation

Oxygen isotope ( $^{18}\text{O}/^{16}\text{O}$ ) and hydrogen isotope ( $^2\text{H}/^1\text{H}$ , or D/H) ratios are measured on an automated gas-source mass spectrometer. Water samples for O-isotope analysis are inlet directly into an automated, computer driven gas equilibration system attached to the mass spectrometer. Hydrogen gas samples are prepared for D/H ratio analysis using conventional reduction methods over zinc beads in closed tubes or equivalent method. The hydrogen gas is inlet to the mass spectrometer through an automated inlet system. Analytical reports are automatically printed and electronically filed in the mass spectrometer computer system.

All stable isotopic data are reported using delta ( $\delta$ ) notation, expressing parts per thousand (‰ or per mil) differences between the isotope ratio of the sample and that of the standard, V-SMOW:

$$\delta^{18}\text{O} \text{ or } \delta\text{D} = ((R_S - R_{\text{V-SMOW}})/R_{\text{V-SMOW}}) \times 1000, \text{ where}$$

$$R = ^{18}\text{O}/^{16}\text{O} \text{ or } \text{D}/\text{H},$$

S = sample, and

V-SMOW = Vienna Standard Mean Ocean Water.

Typical analytical uncertainties (standard deviations from the mean) in the  $\delta^{18}\text{O}$  and  $\delta\text{D}$  values of water samples using the methods and instrumentation described above are  $\pm 0.1$  and  $1.0$  ‰, respectively at the  $2\sigma$  (95%) confidence level.

Cadmium, Iron, and Zinc concentrations were determined by Inductively Coupled Plasma (ICP) spectrometry and are reported as ppm ( $\sim\text{mg/l}$ ). Analytical uncertainties for each element are given in Appendix 2 of this report.

### Sampling Locations

The sampling locations for this investigation are presented in Table 1, below. Phases I (Baseline) and II of this investigation included four periodic samplings of these sites in 1996 (rising flow, peak flow, and decreasing flow).

Phase III of the study consisted of two samplings: March 13, 1997 (rising flow) and May 30, 1997 (decreasing flow). The final two samplings occurred nearly one year after the Phase II samplings of 1996, but differed in one very significant way. During Phase II, no significant rain fell prior to the June, 1996 sampling. In 1997, however, a significant rainfall event occurred between the March and May samplings and the effects of this rain may be discerned as small perturbations on some of the stable isotope trends (see below). Phase III of the study also included fourteen additional sampling locations, as listed in the bottom portion of Table 1, below. Seven of the new samples were of various surface waters, while the remainder were from underground mine waters or groundwaters from wells.

### Results

Tables 2, 3, and 4 show the results of metals, stable isotopic, and field measurements, respectively, carried out in this investigation. Time series plots for all French Gulch samples are included as Appendix 1 of this report. Analytical reports for metals and stable isotope measurements are included as Appendices 2 and 3, respectively.

**Table 1 - Sites Sampled in Phases I through III of the Stable Isotope Investigation**  
**Samples from Phases I (Baseline) and II (Summer, 1996)**

<u>Sample Type</u>	<u>Location</u>	<u>Comments</u>
Groundwaters	MW#3	Contaminated, upper and lower Qal, downgradient from mill tailings and mine site
	MW#9	Clean, lower Qal, upgradient mine discharge
	MW #14	Clean, shale bedrock, at 11-10 fault
	MW #16	Contaminated, shale bedrock at mine site
Mine Water	#3 Relief	Contaminated well at mine site
Mine waste water	SB-RF3	At Roaster Fines
Spring water	KDS	Contaminated, upgradient from mine site
	FG-6C	Contaminated seep, downgradient mine site
French Creek Samples	FC @ CB	Clean, upstream from Country Boy Mine sit above access road and culvert
	FG-7	Contaminated, north inflow to Dead Elk Pond, downstream from mine site
	FG-8	Clean Phase II site, south inflow to Dead Elk Pond, downstream from mine site
Snow	Grab sample	Phase I and Phase III site at MW-9 location

**Samples Added in Phases III Investigation (Spring and Summer, 1997)**

Groundwaters	MW#2	Contaminated, Qal/porphyry, below mine and mill tailings, near new mill tailings well
	MW#11	Clean, shale bedrock, above mine
	MW #12	Clean, porphyry bedrock, above mine
	MW #13	Contaminated, shale bedrock, main mine waste pile
	WTL-02	Mill tailings well near MW-2
Mine Water	Oro	Contaminated, top of mine pool near 70'
Mine Waste Water	WRO-1	Contaminated new RF well, saturated zone
Spring water	1121	Contaminated seep, at base of dredge piles downstream from mine
	FG-6D	Clean Qal? seep from under dredge tailings pile near contaminated seeps
	Qal Seep	At mine site
French Creek Samples	FG-1	Clean, upstream from site for background
	FG-9	Contaminated, near USGS flow gauge at confluence with Blue River
	FG-15	Pool adjacent to creek
	TS-4	USGS site just below Bullhide fault
Snow	Grab sample	Clean, upstream, near FG-1 location
Rain	Grab sample	Clean, near FG-9 site

Table 2. Metals Data for French Gulch Water Samples

Sample	Location	Phase 1 - Baseline (3/20/96)			Phase 2 - First (6/10/96)		
		Cd (ppm)	Fe (ppm)	Zn (ppm)	Cd (ppm)	Fe (ppm)	Zn (ppm)
FG 1, 13	MW-14	0.013	1.7	0.39	0.01	5.9	1.7
FG 2, 12	MW-9	<0.005	0.51	0.092	0.0054	0.46	0.13
FG 3, 18	MW-16	0.046	99.3	96.8	0.072	120	127
FG 4, 16	MW-3	0.12	211	167	0.34	297	277
FG 5, 17	#3 Relief	0.2	188	165	0.63	169	230
FG 6, 20	FC6C spring	0.14	201	159	0.54	165	355
FG 7, 19	KennyDog Spr.	0.072	16.7	8.4	0.017	2.1	9.6
FG 8, 15	Roaster Fines3	<0.5	26,900	4,530	13	4,090	3,160
FG 9, 14	FCreek @ CB	<0.005	2.2	0.4	nd	nd	nd
FG 11, 21	FG7, LowerFC	0.027	1.3	13.4	0.0089	0.64	2.6
FG 22	FG8DeadElkPd	ND	ND	ND	0.0064	0.16	0.76

Sample	Location	Phase 2 - Second (6/27/96)			Phase 2 - Third (7/22/96)		
		Cd (ppm)	Fe (ppm)	Zn (ppm)	Cd (ppm)	Fe (ppm)	Zn (ppm)
FG 24, 37	MW-14	0.0075	15.7	4.3	nd	15.1	4.6
FG 23, 36	MW-9	nd	nd	nd	nd	0.51	0.17
FG 26, 38	MW-16	0.092	117	124	0.058	94.5	106
FG 28, 35	MW-3	0.31	279	256	0.17	338	243
FG 27, 39	#3 Relief	0.72	184	242	0.53	144	199
FG 30	#3 Mine	0.68	164	232	ND	ND	ND
FG 32, 43	FC6C spring	0.61	163	328	0.34	334	285
FG 29, 41	KennyDog Spr.	0.011	11.2	7.9	nd	2.8	6.1
FG 25, 40	Roaster Fines3	15.2	3,750	3,360	13.6	3,940	3,260
FG 31, 42	FCreek @ CB	nd	0.18	0.048	nd	nd	0.025
FG 33, 44	FG7, LowerFC	0.0074	0.28	2.7	0.0073	0.27	4.2
FG 34, 45	FG8DeadElkPd	nd	0.13	0.66	nd	0.13	0.59

Sample	Location	Phase 3 - Fourth (3/13/97)			Phase 3 - Fifth (5/30/97)		
		Cd (ppm)	Fe (ppm)	Zn (ppm)	Cd (ppm)	Fe (ppm)	Zn (ppm)
FG 55, 98	MW-14	0.0059	12.4	1.9	nd	19.4	6.7
FG 56, 99	MW-9	0.0081	0.36	0.085	nd	nd	0.072
FG 58, 104	MW-16	0.13	127	140	0.057	80.6	87.6
FG 60, 110	MW-3	0.16	221	178	0.26	351	325
FG 57	#3 Relief-Well	0.19	155	170	ND	ND	ND
FG 105	#3 Mine	ND	ND	ND	0.41	148	192
FG 64, 89	FC6C spring	0.14	197	164	0.12	236	234
FG 65, 93	KennyDog Spr.	0.051	1.5	3.2	0.022	0.95	1.05
FG 78, 103	Roaster Fines3	8.5	23,100	3,400	14.2	3,240	3,180
FG 66, 90	FCreek @ CB	0.0073	0.021	nd	nd	0.62	0.56
FG 67, 84	FG7, LowerFC	0.026	2.9	15.9	0.011	0.53	4.3
FG 68, 85	FG8DeadElkPd	nd	nd	0.55	nd	0.19	0.85
FG 59, 109	MW-2	0.012	113	66.7	nd	168	14.9
FG 62, 100	MW-11	0.047	nd	3.9	0.076	nd	8.5
FG 69, 97	MW-12	0.0052	0.46	0.14	nd	2.6	0.4
FG 63, 107	MW-13	5.6	11.9	1,550	4.8	14.6	1,280
FG 70, 96	FG-1 creek	nd	0.24	0.034	nd	nd	0.057
FG 73, 82	FG-9 creek	0.011	0.92	4.8	0.0086	0.34	2.7
FG 74, 91	FG-15 pool	nd	2.4	1.2	0.16	4.6	32.1
FG 75, 86	1121 seep	0.043	36.9	54.9	0.06	2	27.8
FG 76, 88	FG-6D seep	0.01	17.1	28.2	0.0097	4.4	12.9
FG 77, 87	TS-4 creek	nd	1.7	0.57	0.0064	0.42	1.6
FG 101	Oro shaft	ND	ND	ND	0.76	20	136
FG 102	WRO-1 well	ND	ND	ND	14.5	1,260	2,750
FG 106	Qal seep	ND	ND	ND	0.079	0.75	20.8
FG 108	WTL-02 well	ND	ND	ND	0.011	86.7	86.8

ND = Not Determined      nd = not detected

Table 3. Stable Isotope Data for French Gulch Water Samples

		Phase 1	Phase 2			Phase 3	
Oxygen Isotopes: $\delta^{18}\text{O}$ (‰ vs V-SMOW)		Baseline	First	Second	Third	Fourth	Fifth
Sample	Location	3/20/96	6/10/96	6/27/96	7/22/96	3/13/97	5/30/97
FG 1,13, 24, 37, 55, 98	MW-14	-17.7	-18.1	-18.8	-18.4	-18.2	-18.3
FG 2,12, 23, 36, 56, 99	MW-9	-18.0	-17.9	-18.0	-17.4	-17.5	-17.7
FG 3,18, 26, 38, 58, 104	MW-16	-18.9	-18.6	-18.8	-18.6	-18.6	-18.3
FG 4,16, 28, 35, 60, 110	MW-3	-18.2	-18.4	-18.6	-18.6	-18.1	-18.2
FG 5,17, 27, 39, 57	#3 Relief	-18.8	-18.5	-18.8	-18.7	-18.5	ND
FG30, 105	#3 Mine	ND	ND	-18.7	ND	ND	-18.5
FG10, 71, 94	Snow at MW-9	-27.2	ND	ND	ND	-23.6	-21.6
FG 6, 20, 32, 43, 64, 89	FC6C spring	-18.7	-18.5	-18.6	-18.0	-18.3	-18.3
FG 7,19, 29, 41, 65, 93	Kenny Dog Spr.	-21.0	-18.6	-18.7	-18.7	-18.7	-18.3
FG 8,15, 25, 40, 78, 103	Roaster Fines3	-17.4	-17.8	-17.8	-17.8	-17.3	-17.2
FG 9,14, 31, 42, 66, 90	FCreek @ CB	-18.0	-18.1	-17.8	-17.8	-17.7	-18.4
FG 11, 21, 33, 44, 67, 84	FG7, LowerFC	-18.1	-18.1	-18.2	-17.8	-17.8	-17.9
FG 22, 34, 45, 68, 85	FG8 DeadElkPd	ND	-18.0	-18.1	-17.9	-17.65	-17.9
FG 72, 95	Snow at FG-1	ND	ND	ND	ND	-22.4	-19.4
FG59, 109	MW-2	ND	ND	ND	ND	-18.2	-18.5
FG 62, 100	MW-11	ND	ND	ND	ND	-17.6	-18.0
FG 69, 97	MW-12	ND	ND	ND	ND	-18.0	-18.1
FG 63, 107	MW-13	ND	ND	ND	ND	-17.3	-17.3
FG 70, 96	FG-1 creek	ND	ND	ND	ND	-17.6	-18.3
FG 73, 82	FG-9 creek	ND	ND	ND	ND	-17.7	-17.8
FG 74, 91	FG-15 pool	ND	ND	ND	ND	-17.8	-17.93
FG 75, 86	1121 seep	ND	ND	ND	ND	-18.0	-18.0
FG 76, 88	FG-6D seep	ND	ND	ND	ND	-17.8	-17.8
FG 77, 87	TS-4 creek	ND	ND	ND	ND	-17.8	-18.0
FG 83	Rain at FG-9	ND	ND	ND	ND	ND	-17.0
FG 101	Oro shaft	ND	ND	ND	ND	ND	-17.6
FG 102	WRO-1 well	ND	ND	ND	ND	ND	-17.7
FG 106	Qal seep	ND	ND	ND	ND	ND	-17.5
FG 108	WTL-02 well	ND	ND	ND	ND	ND	-17.5

		Phase 1	Phase 2			Phase 3	
Hydrogen Isotopes: $\delta^2\text{H}$ (‰ vs V-SMOW)		Baseline	First	Second	Third	Fourth	Fifth
Sample	Location	3/20/96	6/10/96	6/27/96	7/22/96	3/13/97	5/30/97
FG 1,13, 24, 37, 55, 98	MW-14	-132	-134	-142	-131	-141.5	-147.5
FG 2,12, 23, 36, 56, 99	MW-9	-131	-136	-137	-122	-132	-139
FG 3,18, 26, 38, 58, 104	MW-16	-141	-144	-145	-135	-136.5	-148
FG 4,16, 28, 35, 60, 110	MW-3	-136	-143	-139	-135	-139.5	-144
FG 5,17, 27, 39, 57	#3 Relief	-141	-143	-144	-135	-143	ND
FG30, 105	#3 Mine	ND	ND	-146	ND	ND	-147
FG10, 71, 94	Snow at MW-9	-206	ND	ND	ND	-186.5	-173
FG 6, 20, 32, 43, 64, 89	FC6C spring	-141	-143	-139	-136	-146	-149
FG 7,19, 29, 41, 65, 93	Kenny Dog Spr.	-159	-144	-141	-142	-149	-146.5
FG 8,15, 25, 40, 78, 103	Roaster Fines3	-133	-130	-137	ND	-141	-139.5
FG 9,14, 31, 42, 66, 90	FCreek @ CB	-132	-136	-127	-126	-135.5	-142
FG 11, 21, 33, 44, 67, 84	FG7, LowerFC	-132	-137	-127	-127	-137	-141.5
FG 22, 34, 45, 68, 85	FG8 DeadElkPd	ND	-136	-127	-125	-137	-140.5
FG 72, 95	Snow at FG-1	ND	ND	ND	ND	-176.5	-155
FG59, 109	MW-2	ND	ND	ND	ND	-140	-145
FG 62, 100	MW-11	ND	ND	ND	ND	-131	-142.5
FG 69, 97	MW-12	ND	ND	ND	ND	-139.5	-149
FG 63, 107	MW-13	ND	ND	ND	ND	-135.5	-138.5
FG 70, 96	FG-1 creek	ND	ND	ND	ND	-134.5	-139.5
FG 73, 82	FG-9 creek	ND	ND	ND	ND	-138	-141
FG 74, (91,92)	FG-15 pool	ND	ND	ND	ND	-136.5	-140.5
FG 75, 86	1121 seep	ND	ND	ND	ND	-142.5	-141
FG 76, 88	FG-6D seep	ND	ND	ND	ND	-139.5	-142
FG 77, 87	TS-4 creek	ND	ND	ND	ND	-137	-140.5
FG 83	Rain at FG-9	ND	ND	ND	ND	ND	-139.5
FG 101	Oro shaft	ND	ND	ND	ND	ND	-140
FG 102	WRO-1 well	ND	ND	ND	ND	ND	-143.5
FG 106	Qal mine seep	ND	ND	ND	ND	ND	-146
FG 108	WTL-02 well	ND	ND	ND	ND	ND	-138

ND =Not Determined

Table 4. Field Measurements for French Gulch Water Samples

Sample	Location	Phase 1 - Baseline (3/20/96)				Phase 2 - First (6/10/96)			
		Depth to Water (ft)	Temperature (°C)	pH	Conductivity (µS/cm)	Depth to Water (ft)	Temperature (°C)	pH	Conductivity (µS/cm)
FG 1, 13	MW-14	24.00	8.6	6.26	1,885	5.95	10.0	ND	1,879
FG 2, 12	MW-9	20.80	5.0	7.06	260	17.35	4.8	ND	283
FG 3, 18	MW-16	13.57	10.1	5.53	2,450	1.00	9.7	ND	2,790
FG 4, 16	MW-3	16.97	9.4	5.39	2,270	14.27	7.8	ND	3,390
FG 5, 17	#3 Relief Well	13.40	8.1	5.55	2,420	1.40	10.4	ND	2,860
FG30	#3 Mine	ND	ND	ND	ND	ND	ND	ND	ND
FG 6, 20	FC6C spring	NA	7.6	5.35	2,480	NA	11.1	ND	3,110
FG 7, 19	KennyDog Spr.	NA	5.6	6.32	80	NA	8.5	ND	613
FG 8, 15	Roaster Fines3	ND	11.2	2.23	25,500	5.92	13.3	ND	9,910
FG 9, 14	FCreek @ CB	NA	4.6	6.30	180	NA	3.3	ND	86
FG 11, 21	FG7, LowerFC	NA	1.0	6.03	395	NA	3.6	ND	155
FG 22	FG8DeadElkPd	ND	ND	ND	ND	NA	3.9	ND	119

NA = Not Applicable

ND = Not Determined

Sample	Location	Phase 2 - Second (6/27/96)				Phase 2 - Third (7/22/96)			
		Depth to Water (ft)	Temperature (°C)	pH	Conductivity (µS/cm)	Depth to Water (ft)	Temperature (°C)	pH	Conductivity (µS/cm)
FG 24, 37	MW-14	9.88	6.8	ND	1,739	14.45	10.4	ND	1,912
FG 23, 36	MW-9	18.80	6.6	ND	320	18.84	8.0	ND	316
FG 26, 38	MW-16	2.95	10.3	ND	2	6.32	11.2	ND	2,129
FG 28, 35	MW-3	14.78	8.1	ND	2,240	15.75	8.5	ND	2,370
FG 27, 39	#3 Relief Well	1.47	9.9	ND	1,959	3.96	11.4	ND	2,060
FG30	#3 Mine	NA	8.8	ND	1,927	ND	ND	ND	ND
FG 32, 43	FC6C spring	NA	9.9	ND	2,350	NA	7.7	ND	2,380
FG 29, 41	KennyDog Spr.	NA	7.3	ND	391	NA	9.3	ND	425
FG 25, 40	Roaster Fines3	6.49	12.5	ND	9,080	8.45	13.1	ND	9,840
FG 31, 42	FCreek @ CB	NA	5.2	ND	52	NA	7.6	ND	71
FG 33, 44	FG7, LowerFC	NA	7.7	ND	103	NA	11.3	ND	162
FG 34, 45	FG8DeadElkPd	NA	6.5	ND	75	NA	9.8	ND	98

NA = Not Applicable

ND = Not Determined

Sample	Location	Phase 3 - Fourth (3/13/97)				Phase 3 - Fifth (5/30/97)			
		Depth to Water (ft)	Temperature (°C)	pH	Conductivity (µS/cm)	Depth to Water (ft)	Temperature (°C)	pH	Conductivity (µS/cm)
FG 55, 98	MW-14	24.19	4.0	6.83	2,440	4.56	5.0	6.87	3,150
FG 56, 99	MW-9	20.99	2.5	8.10	214	17.60	2.6	7.61	519
FG 58, 104	MW-16	14.19	7.4	6.40	2,690	0.00	9.5	6.37	2,070
FG 60, 110	MW-3	16.78	5.9	6.29	2,650	14.98	5.6	6.16	4,310
FG 57	#3 Relief Well	13.24	8.4	6.16	2,670	ND	ND	ND	ND
FG 105	#3 Mine	ND	ND	ND	ND	NA	8.4	5.74	2,850
FG 64, 89	FC6C spring	NA	6.3	5.65	5677	NA	6.2	6.08	3,900
FG 65, 93	KennyDog Spr.	NA	3.2	6.75	98	NA	6.6	ND	670
FG 78, 103	Roaster Fines3	ND	ND	ND	ND	6.37	11.8	3.76	13,240
FG 66, 90	FCreek @ CB	NA	1.8	7.65	33	NA	2.2	ND	172
FG 67, 84	FG7, LowerFC	NA	1.2	6.89	102.7	NA	2.7	6.93	266
FG 68, 85	FG8DeadElkPd	NA	1.7	7.10	38	NA	2.6	6.77	189
FG59, 109	MW-2	15.28	6.7	6.80	2,770	10.68	5.7	6.92	3,260
FG 62, 100	MW-11	32.22	5.2	6.98	433	23.75	4.7	6.98	895
FG 69, 97	MW-12	26.26	5.7	7.16	52	25.49	6.4	7.69	255
FG 63, 107	MW-13	33.65	6.7	6.15	5,240	14.80	6.4	6.14	5,340
FG 70, 96	FG-1 creek	NA	1.1	7.39	26	NA	1.9	ND	115
FG 73, 82	FG-9 creek	NA	2.4	6.92	80	NA	2.9	7.20	250
FG 74, 91	FG-15 pool	NA	1.7	7.13	40	NA	2.1	4.05	1,000
FG 75, 86	1121 seep	NA	0.9	6.13	267	NA	1.9	ND	930
FG 76, 88	FG-6D seep	NA	1.6	6.29	177	NA	3.4	ND	572
FG 77, 87	TS-4 creek	NA	3.7	7.78	36	NA	2.5	ND	176
FG 101	Oro shaft	ND	ND	ND	ND	67.90	6.9	3.34	2,000
FG 102	WRO-1 well	ND	ND	ND	ND	13.19	11.0	3.67	10,350
FG 106	Qal seep	ND	ND	ND	ND	NA	5.2	6.04	586
FG 108	WTL-02 well	ND	ND	ND	ND	7.65	0.7	6.44	2,260

NA = Not Applicable

ND = Not Determined

### Stable Isotopic Compositions of French Gulch Precipitation

Figure 1 shows the oxygen and hydrogen isotope compositions of all precipitation (snow and rain) samples collected in 1996 and 1997. When plotted on a conventional meteoric water line diagram, the data array form a line with a slope similar to that of the Global Meteoric Water Line (MWL), but four of the five samples are slightly displaced to the right of the MWL. Sublimation of snow does not change the stable isotopic compositions, but shifts to the right (or below) the MWL are characteristic of evaporation prior to sampling. The Baseline snow sample at the MW-9 site in March, 1996 had the lightest (most negative) stable isotopic composition ( $\delta^{18}\text{O} = -27.2\text{‰}$ ). A subsequent snow sample from this site in March, 1997 showed a considerably higher value ( $-23.6\text{‰}$ ), attesting to strong climatic variability in the annual stable isotopic signatures of snowfall in Colorado. A final snow sample from this site, collected in May, 1997 yields an even higher (less negative)  $\delta^{18}\text{O}$  value, due either to evaporation or to mixing with higher- $^{18}\text{O}$  rainwater (or both). A snow samples from the FG-1 site ( $\delta^{18}\text{O} = -22.4\text{‰}$  in March, 1997) is similar to the MW-9 snow sample of the same date, while a final snow sample from FG-1 is enriched in  $^{18}\text{O}$ , again due to evaporation and/or incorporation of higher- $^{18}\text{O}$  rainfall. Finally, a rainfall sample at FG-1 had the highest  $\delta^{18}\text{O}$  value of any water sample analyzed in this investigation ( $\delta^{18}\text{O} = -17.0\text{‰}$ ). This relatively  $^{18}\text{O}$ -rich rainfall signature is not unexpected, since local groundwater must be a mixture of low- $^{18}\text{O}$  snowmelt and higher- $^{18}\text{O}$  rainfall, with the groundwater stable isotopic compositions falling in between the two precipitation sources.

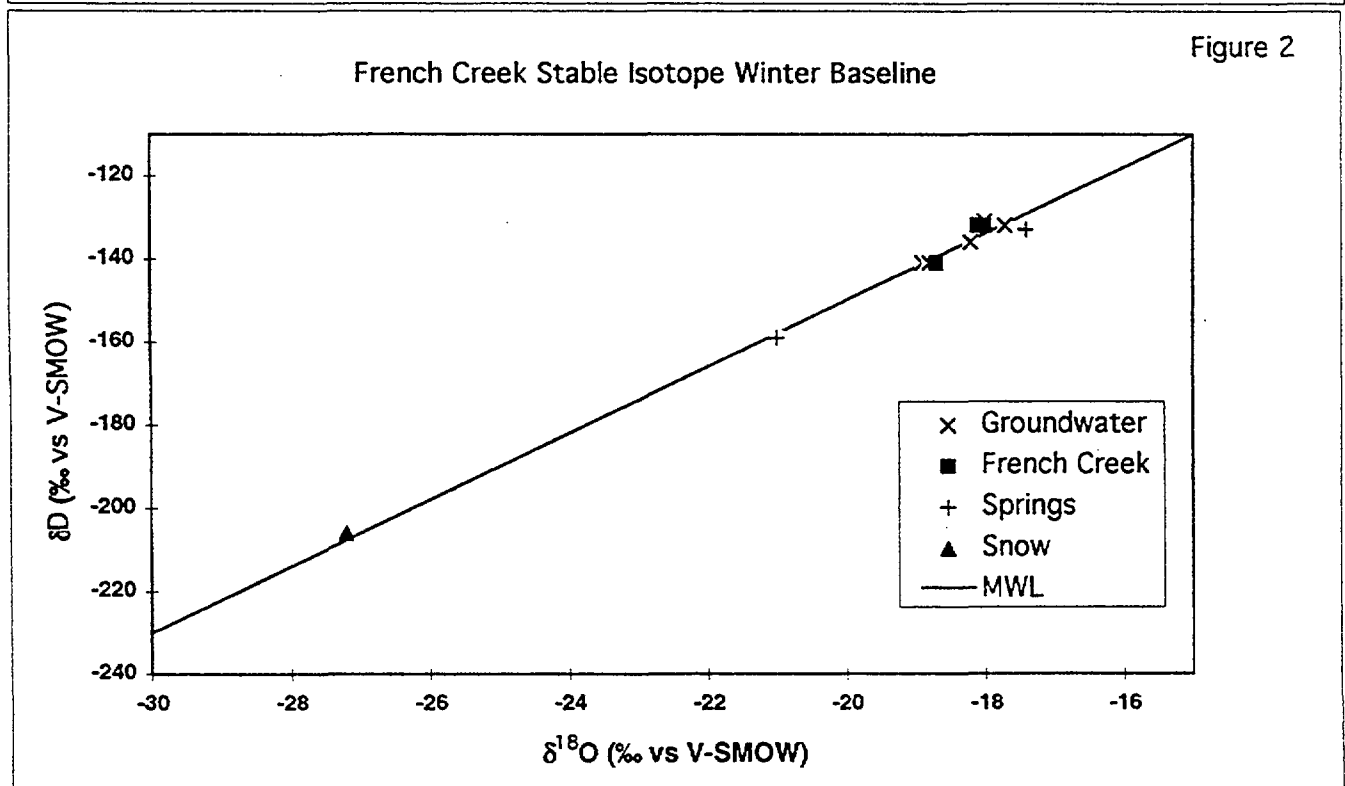
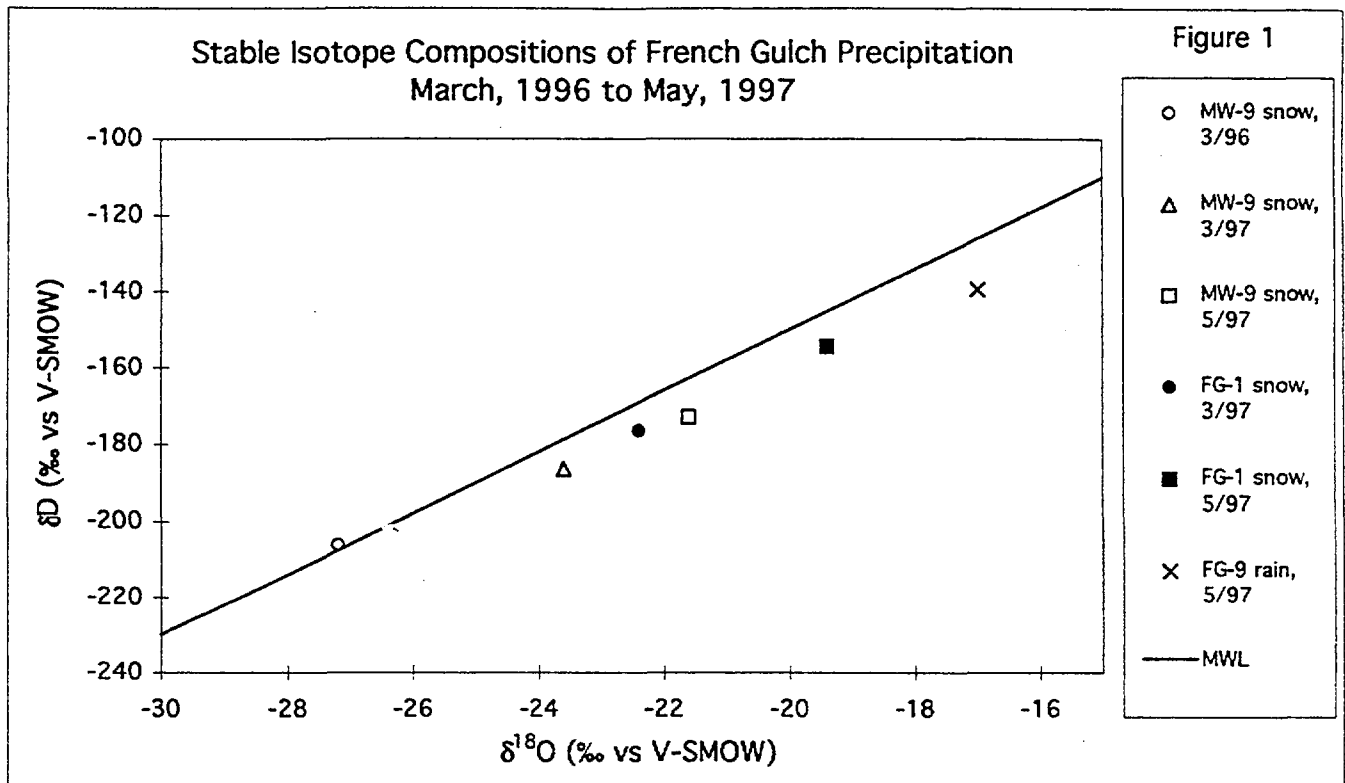
### Implications of Phase I (Baseline) Isotopic Results

The stable isotopic results for Phase I samples, collected in March, 1996 at a time of minimum water levels and low stream flow, are shown on Figure 2. All Baseline samples fall on or near the global meteoric water line (MWL), indicating that the data are reasonably accurate and precise, and that none of the samples has suffered large amounts of evaporation. The position of the two spring samples slightly to the right of the global MWL, however, may indicate minor evaporation prior to sampling (Figure 2).

In general, the  $\delta^{18}\text{O}$  and  $\delta\text{D}$  values of French Gulch water samples covary linearly as with all meteoric waters. Further discussions of stable isotope data, therefore, will focus solely on the oxygen isotope compositions. All conclusions based on the oxygen isotopes are, of course, also valid for the hydrogen isotopes.

The isotopic similarity of local groundwaters and samples from French Creek implies that *the principal source of water in French Creek in mid-winter is groundwater*. The considerable oxygen isotopic contrast between local groundwaters/French Creek samples ( $\delta^{18}\text{O} = -18.3 \pm 0.6\text{‰}$ ) and the mid-winter 1996 snowpack ( $\delta^{18}\text{O} = -27.2\text{‰}$ ) are extremely favorable for conducting isotopic mass balance studies during the snowmelt event. Given the analytical uncertainty of  $\pm 0.1\text{‰}$  for O-isotopic data on water samples, it has been possible to estimate snowmelt vs. groundwater contributions to French Creek during the 1996 snowmelt event with an accuracy of approximately 2% (as illustrated below).

The distinctive stable isotopic composition of the Baseline Kenny Dog Spring (KDS) sample (Figure 2) indicates that the KDS waters contained a significant proportion of local snowmelt. Field observations at the time of sampling (W. Pedler, pers. comm. to BMS) are consistent with this conclusion. If it is assumed that (1) KDS water had an original  $\delta^{18}\text{O}$  value of  $-17.4\text{‰}$  (identical to most  $^{18}\text{O}$ -rich French Creek and local groundwater samples measured in Phase 1 of



this investigation), and (2) French Gulch snowmelt had a  $\delta^{18}\text{O}$  value of  $-27.2 \pm 0.1$  ‰ (as measured), then the calculated proportion of snowmelt in the KDS sample ( $\delta^{18}\text{O} = -21.0 \pm 0.1$  ‰) is  $37 \pm 2\%$ . This example illustrates the stable isotopic mass balancing capabilities for simple, two-component water mixtures.

Although there are strong correlations between metals contamination, low pH, and high electrical conductivity, Figures 3a-c show that there is no striking correlation between metal concentrations and stable isotope composition of French Gulch surface waters (filled squares and pluses) and groundwaters ("x"s) in the winter of 1996. Under the hydrologic conditions in which the Baseline investigation was conducted (winter with no significant snowmelt), French Creek samples and most springs have isotopic compositions strikingly similar to local groundwater. *Contaminated groundwaters, therefore, are likely to have been responsible for the mid-winter metal contamination measured in one of the mid-winter French Creek samples.* Other contaminated surface waters such as the waste waters at the Roaster Fines, also exhibited stable isotopic compositions similar to local groundwater in the winter of 1996, suggesting a similar origin.

### Changes in Water Levels during the Snowmelt Event

Figures 4a and 4b show the relative changes in water level for the five wells sampled during this investigation plotted against the number of days since the Baseline sampling. These figures reveal that:

- Three wells in the shale aquifer (MW-14, MW-16, and #3 Relief) showed a marked increase in water level during the first 60 days, followed by a decline in the ensuing 50 days. In the Spring of 1997, these three wells showed an increase in water level similar to, or slightly larger than the increases measured in the Spring of 1996.
- The two wells in the alluvial aquifer (MW-3 and MW-9) showed similar, less pronounced increases in water level in each of the Spring sampling periods.
- The peak water levels occurred approximately 60 days after the Baseline sampling. Thereafter, water levels begin to return to low-flow conditions, a process that was apparently complete ~160 days after the Baseline sampling (i.e., in early September, 1996).
- Monitoring wells MW-11 and MW-13, both completed in shale bedrock, showed significant rises in water level during the Spring of 1997, similar to the large rises observed in shale monitoring wells in the Spring of 1996. Conversely, 1997 monitoring wells completed in porphyry bedrock (MW-2 and MW-12) showed much smaller rises in water level in the Spring of 1997, similar to the small rises observed for alluvial wells in the Spring of 1996.

### Oxygen Isotopic Response to the Snowmelt Events

Figures 5a and 5b (detail) illustrate the oxygen isotopic compositions of well, spring, and French Creek samples through six samplings extending over fourteen months, from the 1996 mid-winter Baseline (3/20/96) to late Spring of the following year (5/29/97). Figure 5a also shows the oxygen isotopic compositions of three snow samples collected at the MW-9 site over the course of the study.



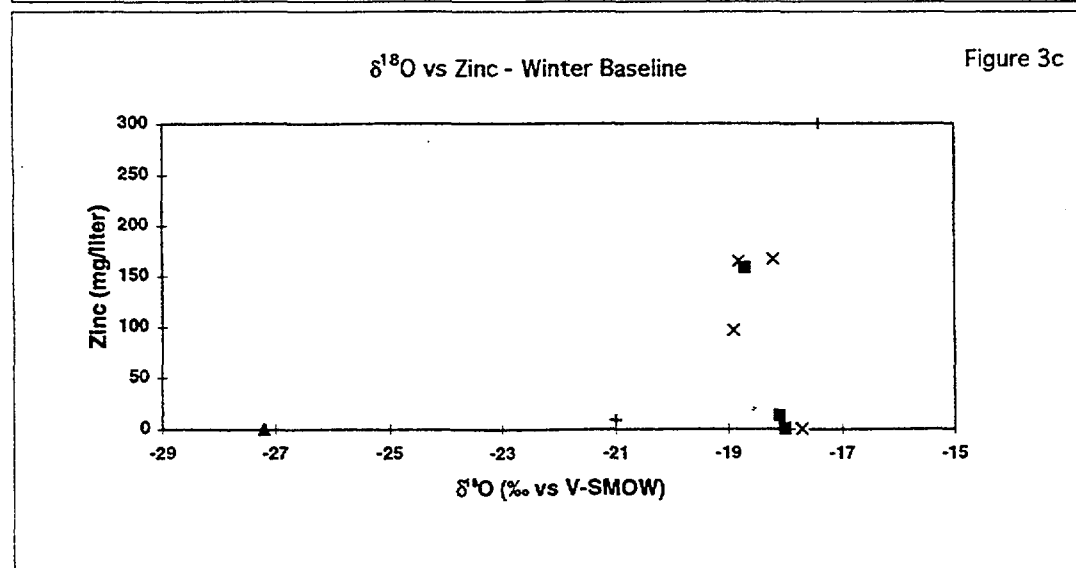
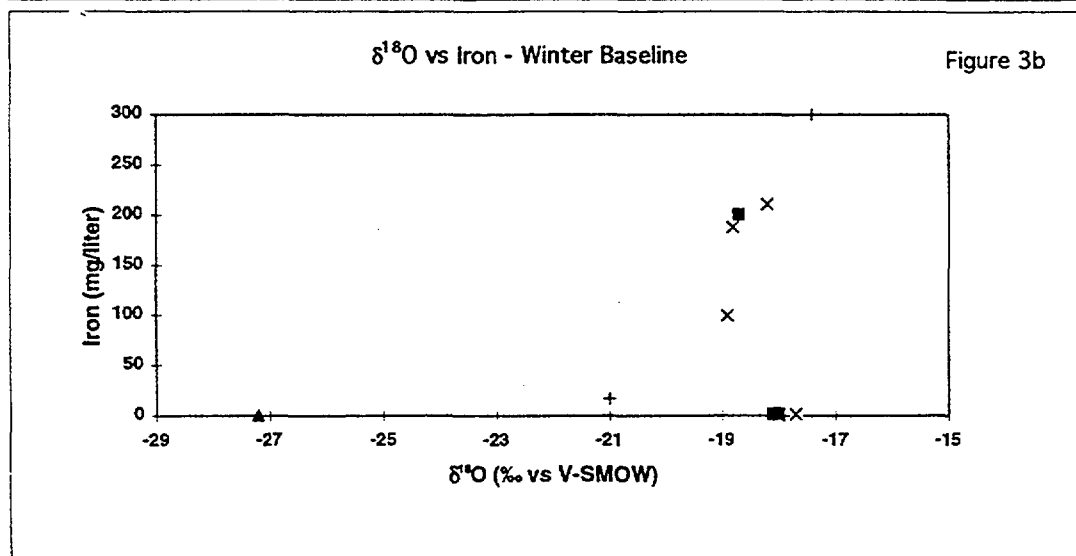
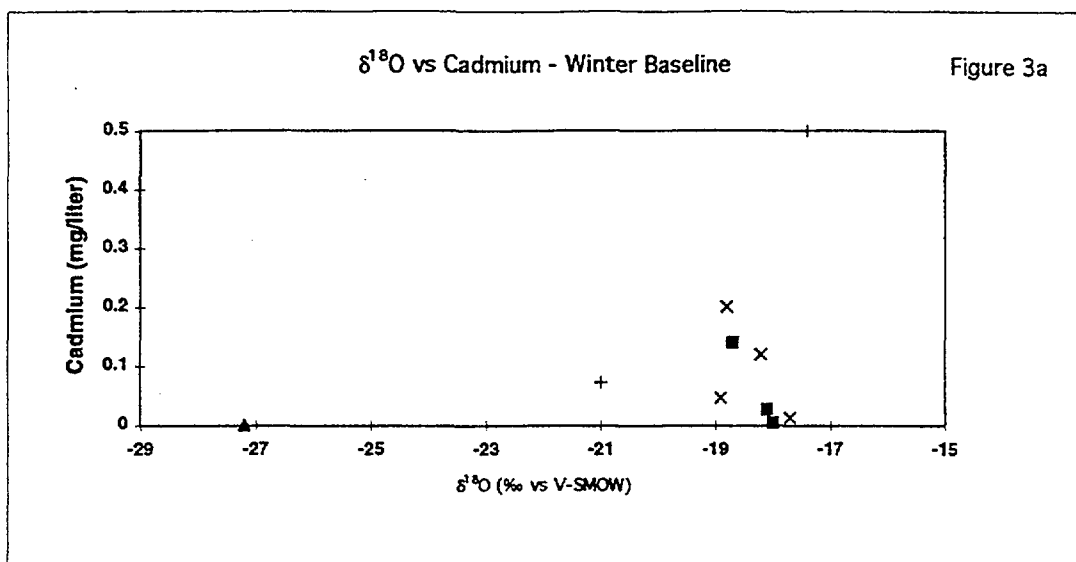


Figure 4a

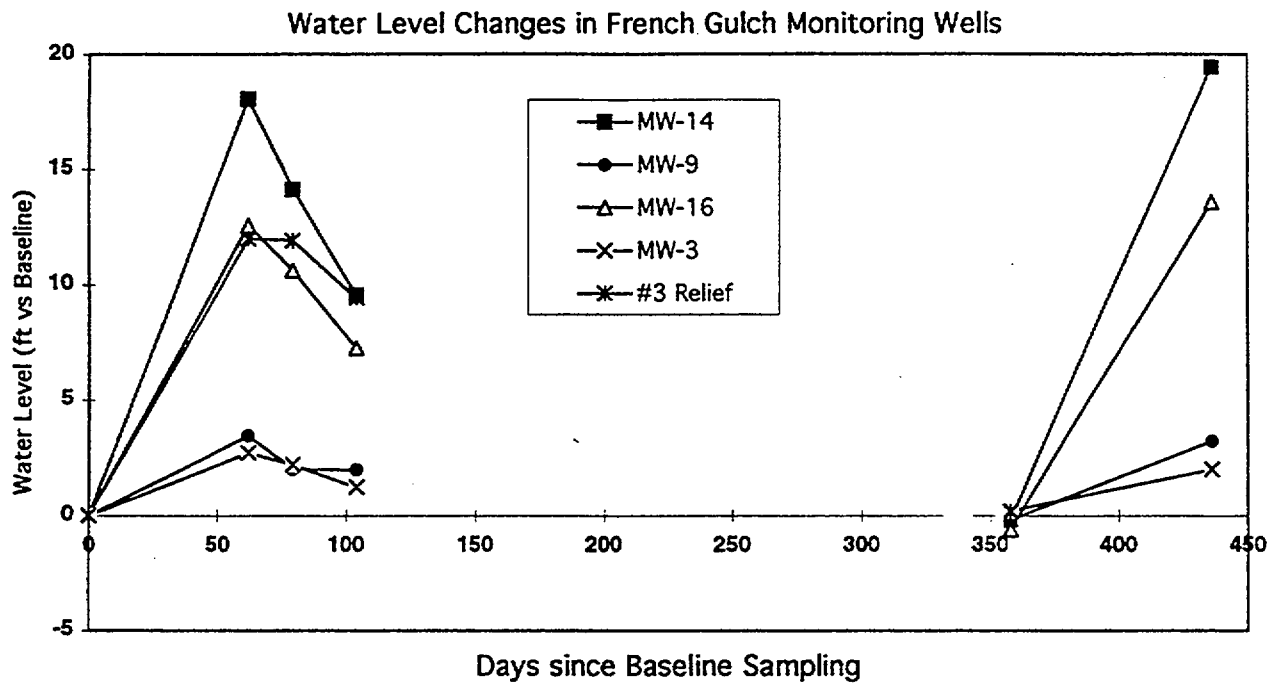
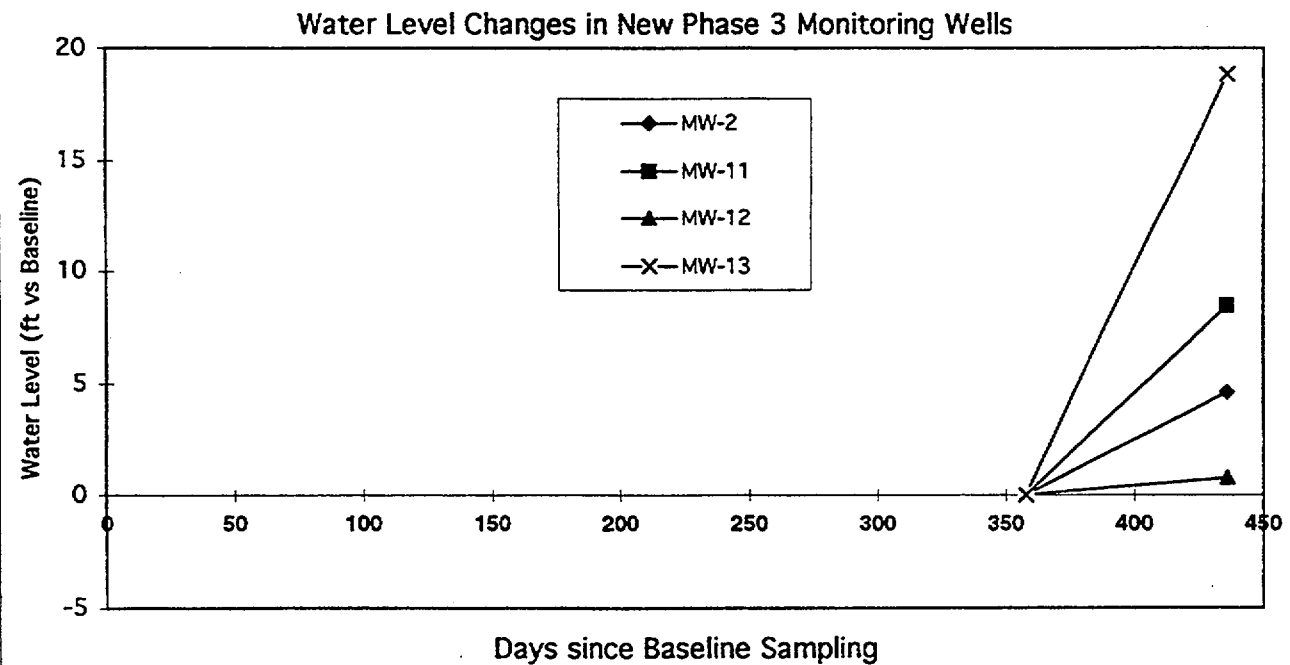


Figure 4b



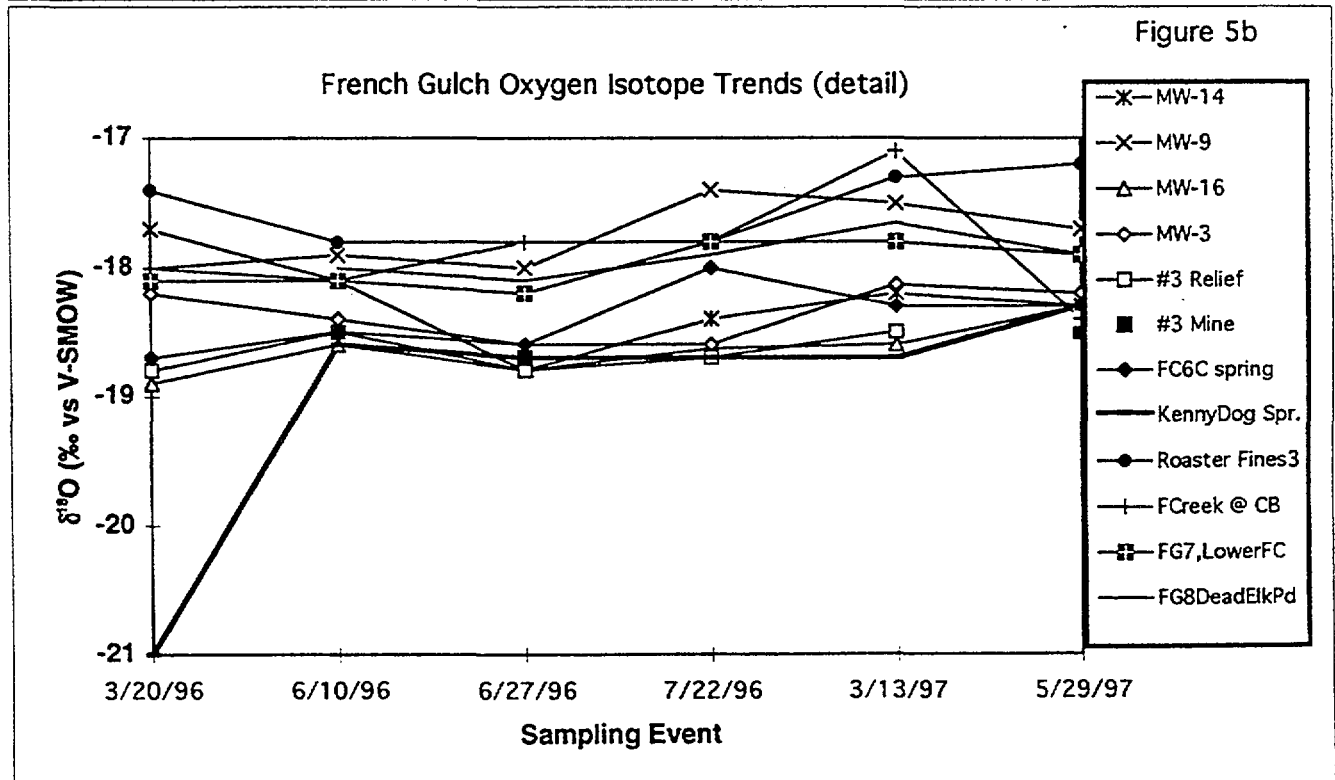
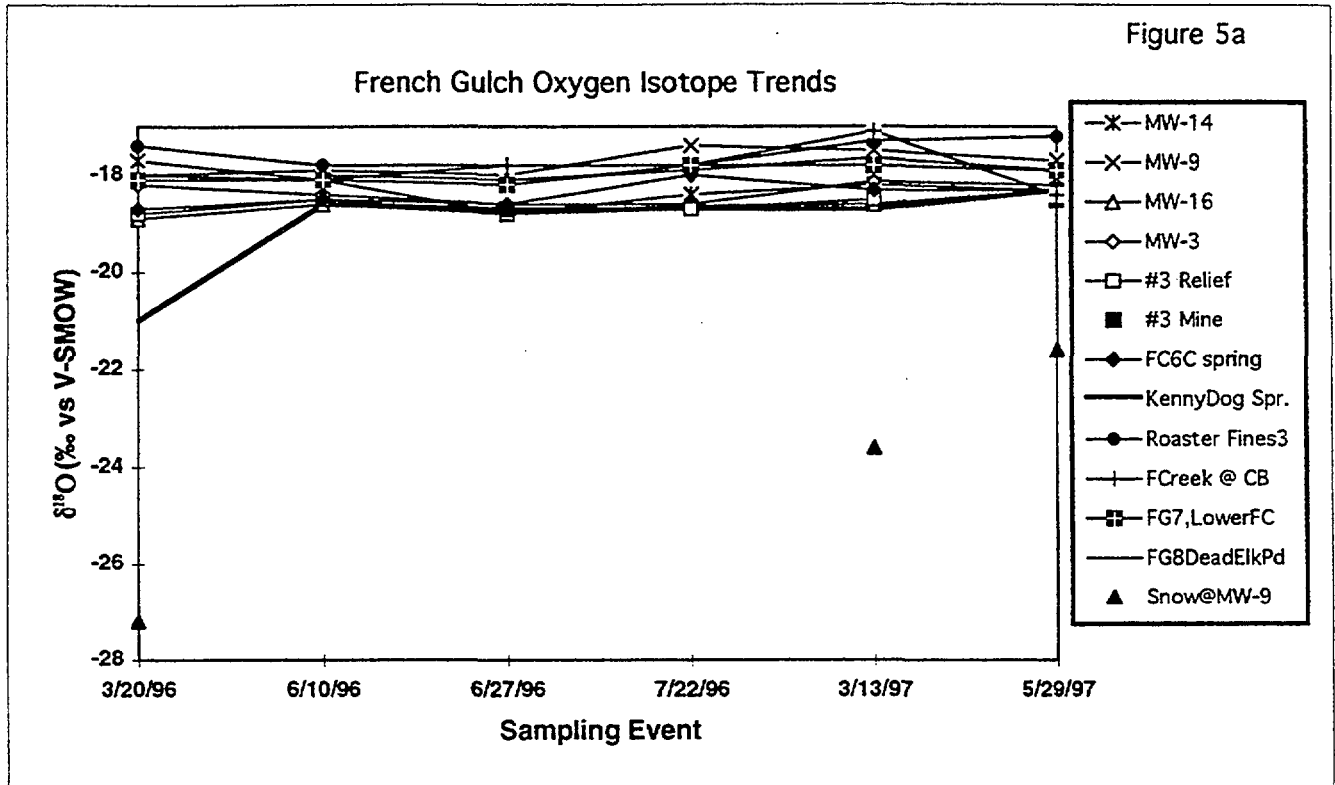


Figure 5c

Oxygen Isotope Data, Phase 3 Samples

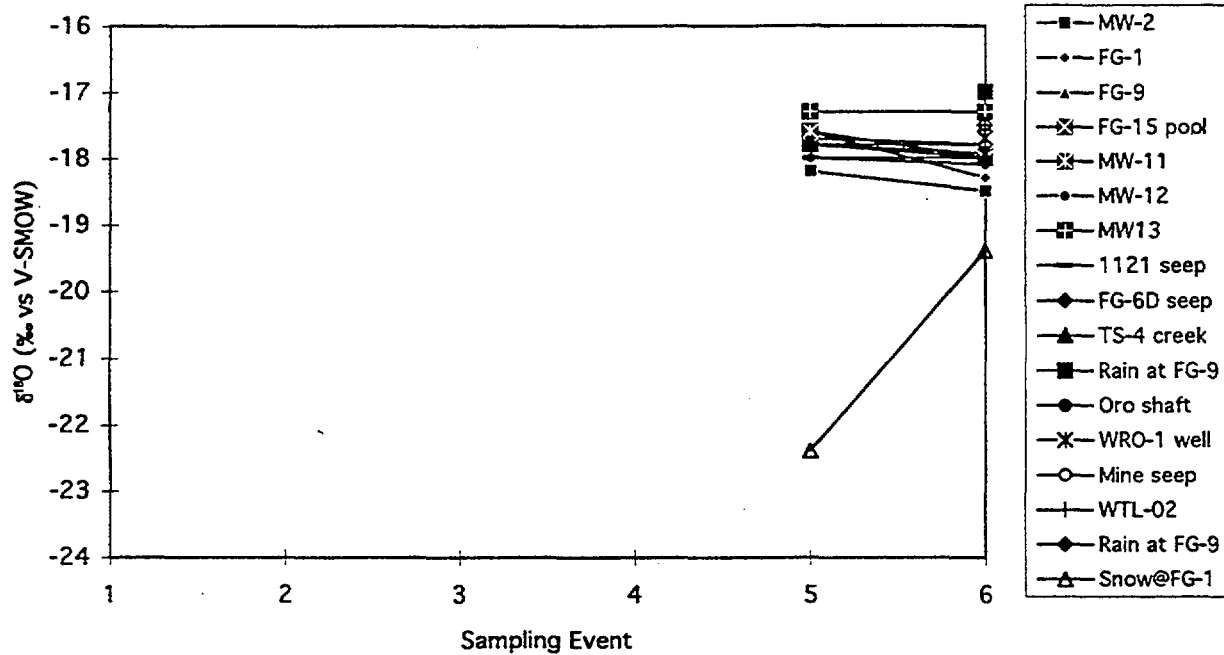
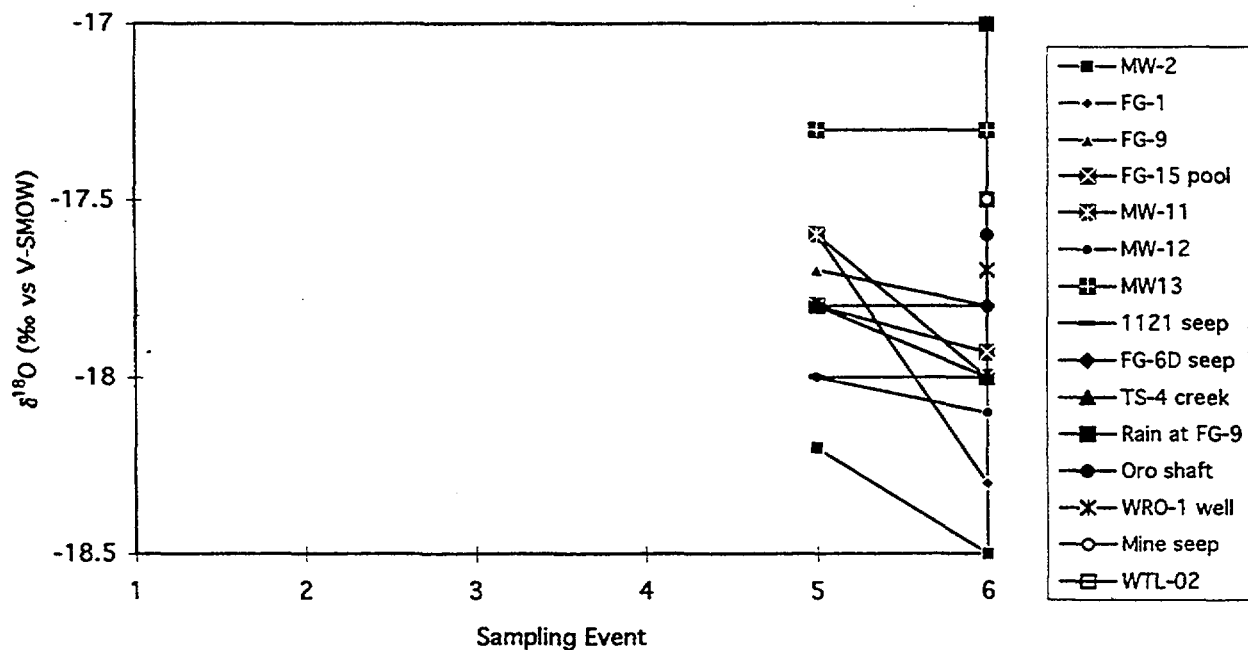


Figure 5d

Oxygen Isotope Data, Phase 3 Samples (Detail)



The only water sample that shows a large oxygen isotopic shift from the Baseline value is that from Kenny Dog Springs, which had a  $\delta^{18}\text{O}$  value indicating considerable contamination with local snowmelt during the Baseline sampling (see above). In all subsequent samplings, however, Kenny Dog Spring yielded water that was isotopically similar to the lowest- $^{18}\text{O}$  groundwater, spring, and stream samples. Thus, the post-baseline samples from Kenny Dog Springs were not particularly contaminated with local snowmelt.

The most striking aspect of the data shown on Figures 5a and 5b is the nearly unchanging stable isotopic composition of all French Gulch samples over time, despite the fact that the samples were collected at different times before and during two successive snowmelt events, and at times of highly contrasting water table elevations and surface water flow rates. Figures 5c and 5d show that the stable isotope uniformity is also seen in the new Phase 3 samples from French Gulch monitoring wells, seeps and Creek samples, which all have  $\delta^{18}\text{O}$  values of -17.5 to -18.5 ‰.

### Evidence for Minor Contributions of Snowmelt to French Creek and Local Aquifers

The near uniformity of the stable isotopic compositions of Creek, well, and spring samples through the Springs of 1996 and 1997 prohibits the direct addition of large amounts of snowmelt into French Creek within or upgradient from the study area. Substantial amounts of snowmelt entering the Creek must first be mixed with very large amounts of higher- $^{18}\text{O}$  water to produce the isotopic compositions measured in the Creek. This implies that the travel time for much of the water entering the Creek is long enough to allow considerable mixing with infiltrated rain water and groundwater. This, of course, allows considerable time for chemical interactions between the shallow groundwaters and mineralized rocks of the area.

Figure 6 shows the maximum amount of local snowmelt ( $\delta^{18}\text{O} = -27.2$  ‰, the measured value for snow at MW-9 in 1996) that could have mixed with local "end member" groundwater with a  $\delta^{18}\text{O}$  of -17.4 ‰ (the highest measured value for a French Gulch groundwater or spring sample in 1996). Apart from the Baseline sample from Kenny Dog Springs, groundwaters, spring waters, and French Creek waters could have a maximum of ~15% snowmelt at the height of the snowmelt event. It is, however, probable that snowmelt contributes an even smaller percentage of the total water flowing in French Creek, given that the stable isotopic compositions of French Creek samples changed so little during the first four sampling events. Indeed, the very small changes in the oxygen isotopic compositions of French Creek samples from low-flow through high-flow conditions (Figures 5a and 5b) indicates that the proportion of snowmelt in the Creek during high flow conditions could only have been a few percent in 1996; that is, near the limit of resolution of the rather sensitive stable isotopic methods used in this investigation. Significant additions of undiluted snowmelt are indicated only for those sampling sites showing a lowering of  $\delta^{18}\text{O}$  values at times of high groundwater level and high creek flow (Figures 5a to 5d).

The changes in water levels and oxygen isotope compositions in the samples collected in March and May, 1997 are more difficult to evaluate because a significant rainfall event occurred in the study area soon after the March sampling. Nevertheless, Figure 6b shows systematic downward  $^{18}\text{O}$  shifts of -0.7 ‰ for French Creek just above the 11-10 fault at Country Boy Mine and 1.5 miles above the Oro Mine at site FG-1. This implies that the upper reaches of the Creek contain approximately 10% snowmelt, assuming  $\delta^{18}\text{O}$  values of -17.4 ‰ for groundwater and -27.2 ‰ for snowmelt. The three French Creek sampling sites below the Oro Mine area show significantly higher  $\delta^{18}\text{O}$  values, implying that, in addition to mine waters observed to contaminate French Creek, *large amounts of higher- $^{18}\text{O}$  groundwater must enter the Creek between the 11-10 and Bullhide faults.* This groundwater may carry much of the metals load to the Creek.

Figure 6a

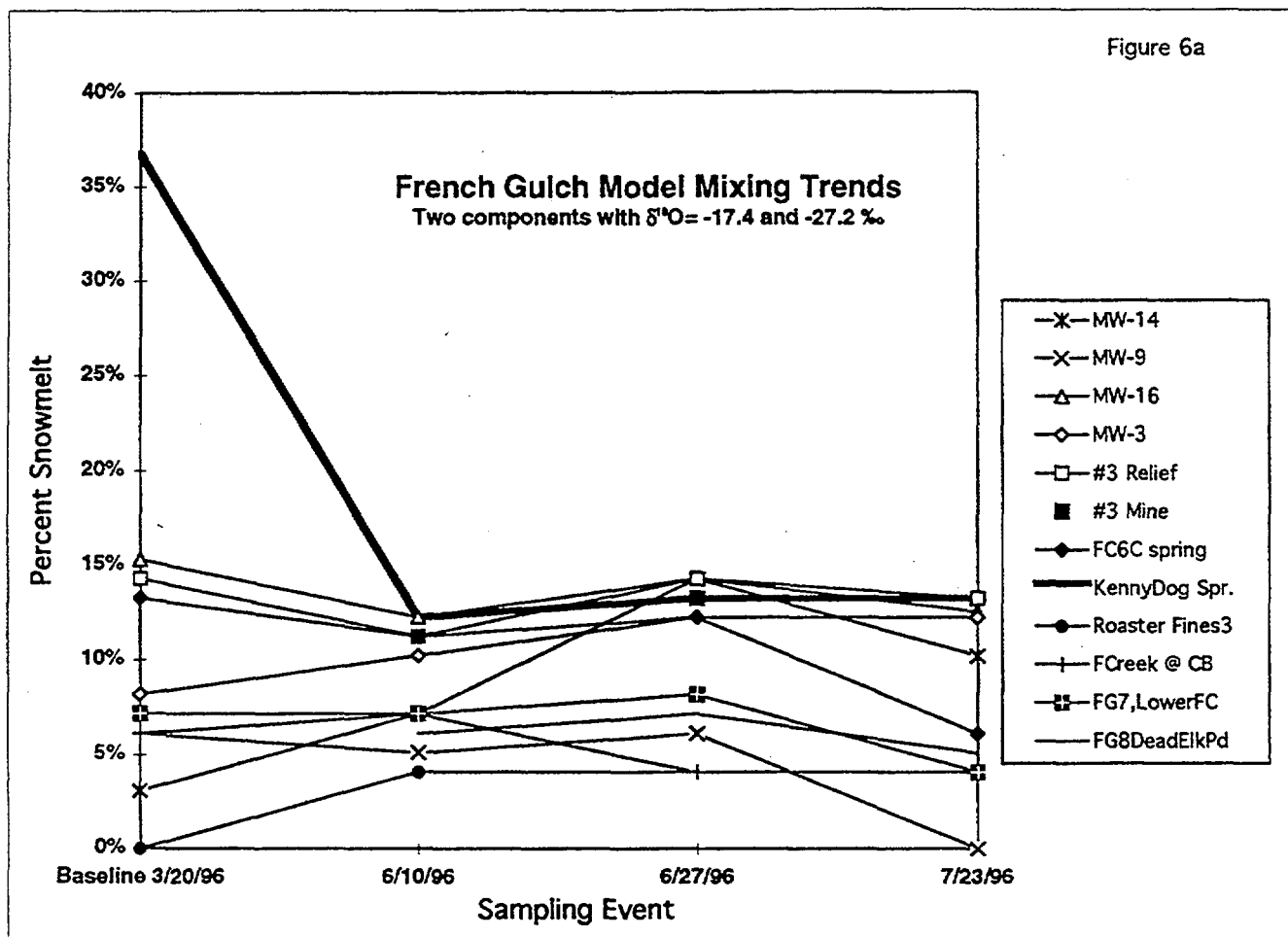
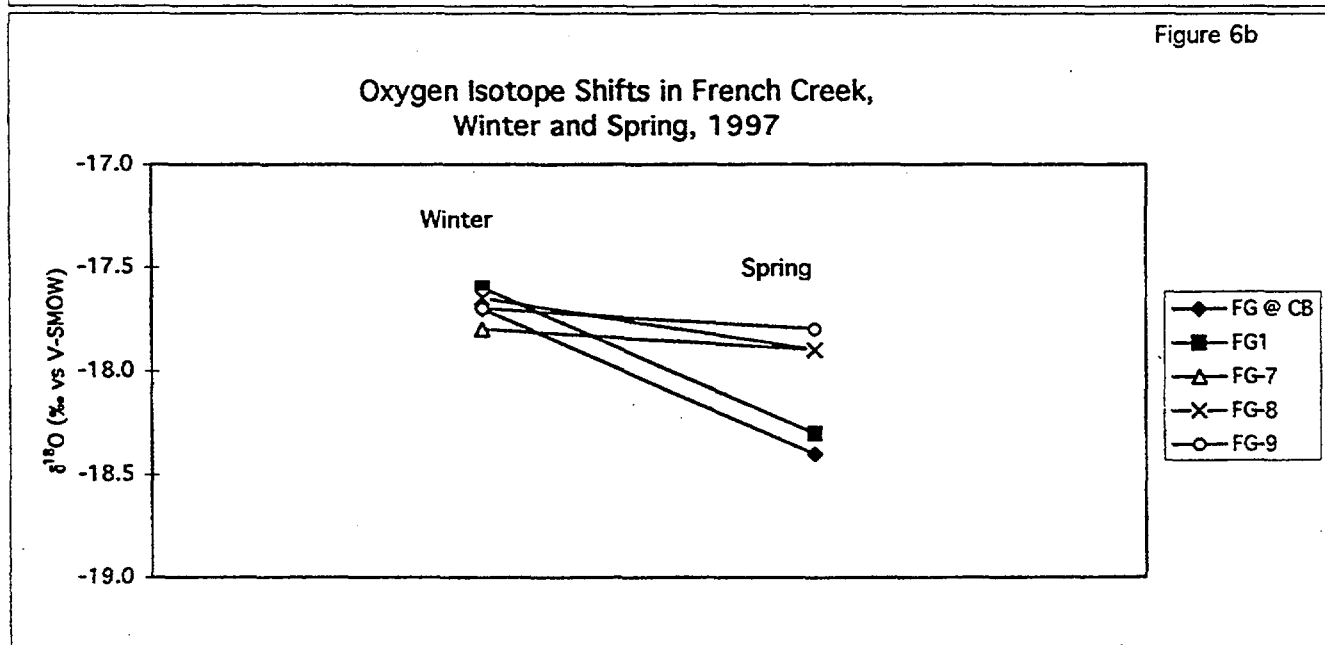


Figure 6b



It bears repeating that water flowing in French Creek during the 1996 and 1997 flow crests had oxygen (and hydrogen) isotopic compositions comparable to those of local groundwaters and springs. These groundwaters may contain a small component of snowmelt, but any mixing between snowmelt and preexisting groundwaters apparently occurred somewhere upslope of the French Gulch mining area. This snowmelt must have mixed with very large volumes of higher- $^{18}\text{O}$  groundwaters composed largely of older groundwater and summer precipitation. In general, the rising flow of French Creek during the Spring must be mostly a consequence of vigorous spring activity, rather than runoff of freshly melted snow.

### Stable Isotopic Groupings

Despite the general uniformity in the stable isotopic compositions of French Gulch water samples in 1996, small but consistent differences in the  $\delta^{18}\text{O}$  values shown on Figures 5a and 5b allowed us to tentatively categorize the samples into three groups, as follows:

1. An  $^{18}\text{O}$ -rich group that consistently had  $\delta^{18}\text{O}$  values between -17.4 and -18.2 ‰ in 1996. This group included:
  - monitoring well MW-9 (uncontaminated, alluvial aquifer)
  - Roaster Fines site (highly contaminated. This water exhibited a slightly lower  $\delta^{18}\text{O}$  value in the most recent 1997 sampling (-18.4 ‰), perhaps indicating the addition of a small amount of lower- $^{18}\text{O}$  water prior to that sampling.
  - French Creek sites (Country Boy Mine, Dead Elk Pond, and Lower French Creek). Note that the final 1997 sample from French Creek at Country Boy Mine shifted to a considerably lower  $\delta^{18}\text{O}$  value (-18.4 ‰) from earlier values of -17.7 to -18.4, interpreted to reflect local snowmelt entry above the 11-10 fault in 1997. This indicates that the Country Boy Mine site should probably be classified with the Group 3 samples, below.
2. An  $^{18}\text{O}$ -depleted group that consistently had  $\delta^{18}\text{O}$  values between -18.5 and -19.0 ‰ in 1996. This group included:
  - monitoring well MW-16 (contaminated, shale aquifer at mine site). This site yielded a slightly higher values of -18.3 ‰ in the most recent sampling.
  - Kenny Dog Springs (post-Baseline samples). This site yielded a slightly higher values of -18.3 ‰ in the most recent sampling.
  - the contaminated #3 Relief well and #3 Mine site. In the 1997 samplings, the Relief Well and mine water samples continued to yield values of -18.5 ‰.

Although a change of only 0.2 ‰ is barely observable, these shifts may indicate the addition of relatively high- $^{18}\text{O}$  rain water in the MW-16 and Kenny Dog Springs samples. Note that the stable isotopic data for the Baseline Kenny Dog Springs sample shows that this spring is susceptible to contamination by surface waters.
3. This group of water samples exhibited shifting oxygen isotope composition with time. This group included:
  - monitoring wells MW-14, uncontaminated shale aquifer
  - MW-3 (contaminated alluvial aquifer)
  - French Gulch 6C spring.

In the 1997 samplings, all of the Category 3 samples continued to shift, rebounding somewhat towards the values measured in the Baseline study. This suggests that the waters sampled at these sites are mixtures of isotopically distinct waters, and that local permeability is high enough to allow different water mixtures to be sampled at different times of the year. The stable isotopic shifts at these sampling sites may indicate rapid water transport between the surface and the sampled portions of monitoring wells MW-3 and MW-14 (see below).

Although the above groupings are based on rather small differences in oxygen isotope composition, the isotopic trends serve to constrain conceptual models for the overall water balance in French Gulch and for processes controlling metals contamination in local waters. It is clear, for example, that a model involving the simple mixing of large amounts of two, isotopically distinct waters is too simple to explain the data. Because different sampling areas show contrasting isotopic and hydrologic properties, it is necessary to examine water levels, metals loading, and stable isotope relations in individual wells and springs to learn more about the mechanisms of metal contamination.

### Oxygen Isotope Compositions of New Phase 3 Samples

The O-isotopic compositions of waters first sampled in 1997 (Phase 3) are shown on Figures 5c and 5d (detail). The overall range in  $\delta^{18}\text{O}$  values for Phase 3 groundwater, springs, and Creek samples (-17.3 to -18.5 ‰) is similar to the overall range exhibited by Baseline and Phase 2 samples (-17.4 to -18.9 ‰, with the exception of the Baseline sample from Kenny Dog Springs). Based on the oxygen isotope compositions of the March and May, 1997 analyses, these new samples are assigned to the oxygen isotopic categories, as follows:

1. With the exception of one groundwater sample, all Phase III waters would be classified in Category 1, an  $^{18}\text{O}$ -rich group that consistently had  $\delta^{18}\text{O}$  values between -17.4 and -18.2 ‰ in 1996. This group is redefined to an  $^{18}\text{O}$ -rich limit of -17.3 ‰, to accommodate the samples from MW-13.
2. One sample (MW-2) yielded  $\delta^{18}\text{O}$  values of -18.2 and -18.5 ‰ in the 1997 samplings, indicating a possible affiliation with Category 3 samples, i.e., sites that exhibit shifting stable isotopic compositions.

In general, the conclusions based on the Phase 1 and Phase 2 sampling are corroborated by the results of the Phase 3 investigation.

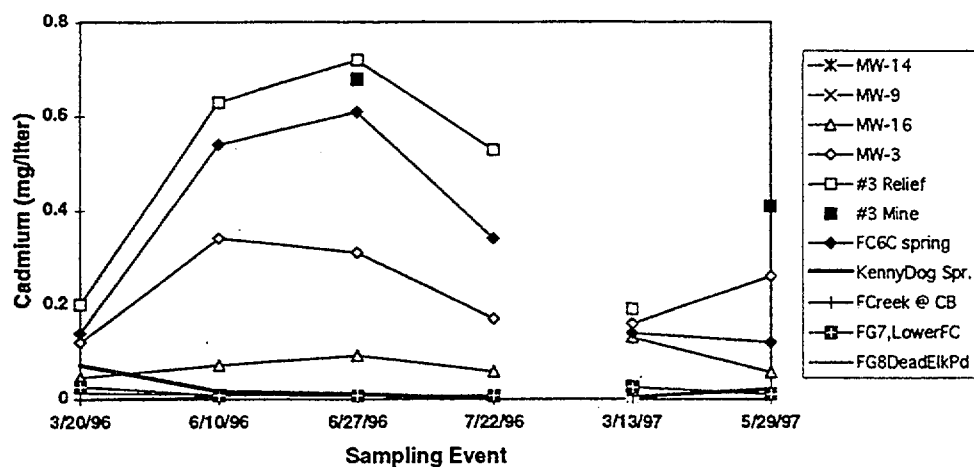
### Evidence for Increased Surface Water Metal Loading during the Snowmelt Events

Figure 7a shows Cd concentrations for French Gulch samples for the six sampling events. Note that the Roaster Fines sample is not plotted because it has a very high Cd concentration that is off scale compared to the other analyzed samples. Samples from four contaminated sites show slightly (MW-16) to strongly (MW-3, FC6C Spring, and #3 Relief Well and Mine) rising Cd concentrations during the time of rising water levels and rising flow in French Creek in the Spring of 1996, and falling Cd concentrations as the watershed began to return to lower flow conditions in the Summer of 1996. Two of these sites show a different behavior in the Spring of 1997; both the MW-16 well and the FG6C spring show reduced Cd concentrations during the time of rising water level. All other sampled sites either exhibit falling Cd concentrations (Kenny Dog Spring) or consistently low Cd concentrations.



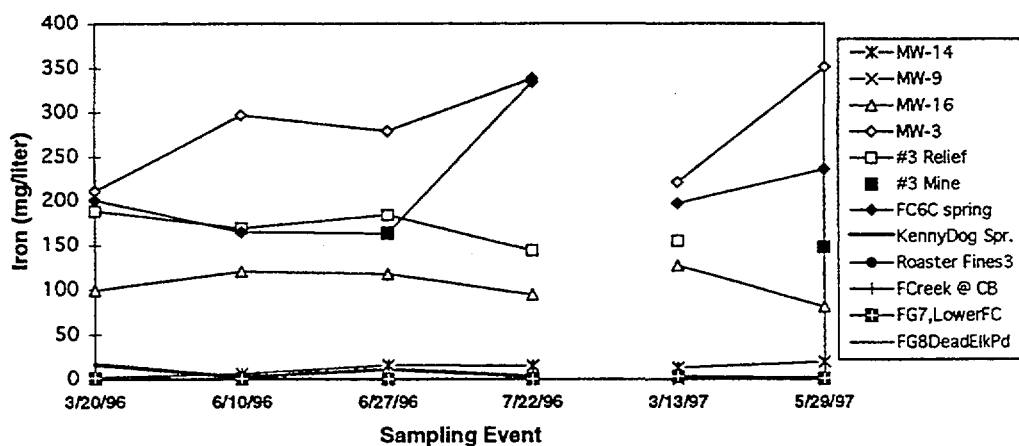
French Gulch Cadmium Trends

Figure 7a



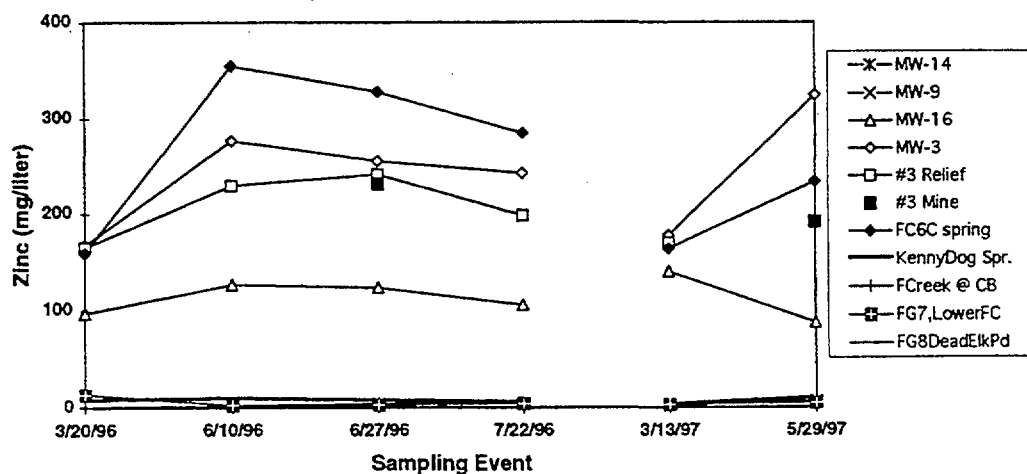
French Gulch Iron Trends

Figure 7b



French Gulch Zinc Trends

Figure 7c



Figures 7b and 7c show Fe and Zn concentrations, respectively, for French Gulch samples for the six samplings. Again, the Roaster Fines samples are not plotted because they have much higher Fe and Zn concentrations than the other samples. It is clear that the same four sites (and, of course, the Roaster Fines site) show the highest concentrations of Cd, Fe and Zn. In addition, there is a positive correspondence with high water levels in French Gulch monitoring wells (compare with Figures 4a and 4b) for both Cadmium and Zinc. Iron, however, shows similar or rising concentrations throughout the course of the investigation for some sampling sites, implying that Fe loading in French Gulch groundwater and in French Creek is not fully coupled with Cadmium and Zinc loading. Indeed, Figures 7a and 7b show that Fe in the 6C spring is rising while Cd is falling in the Spring of 1997, another indication of decoupling between Fe loading and Cd/Zn contamination.

### Evidence Against Surface Water Infiltration in Three French Gulch Monitoring Wells

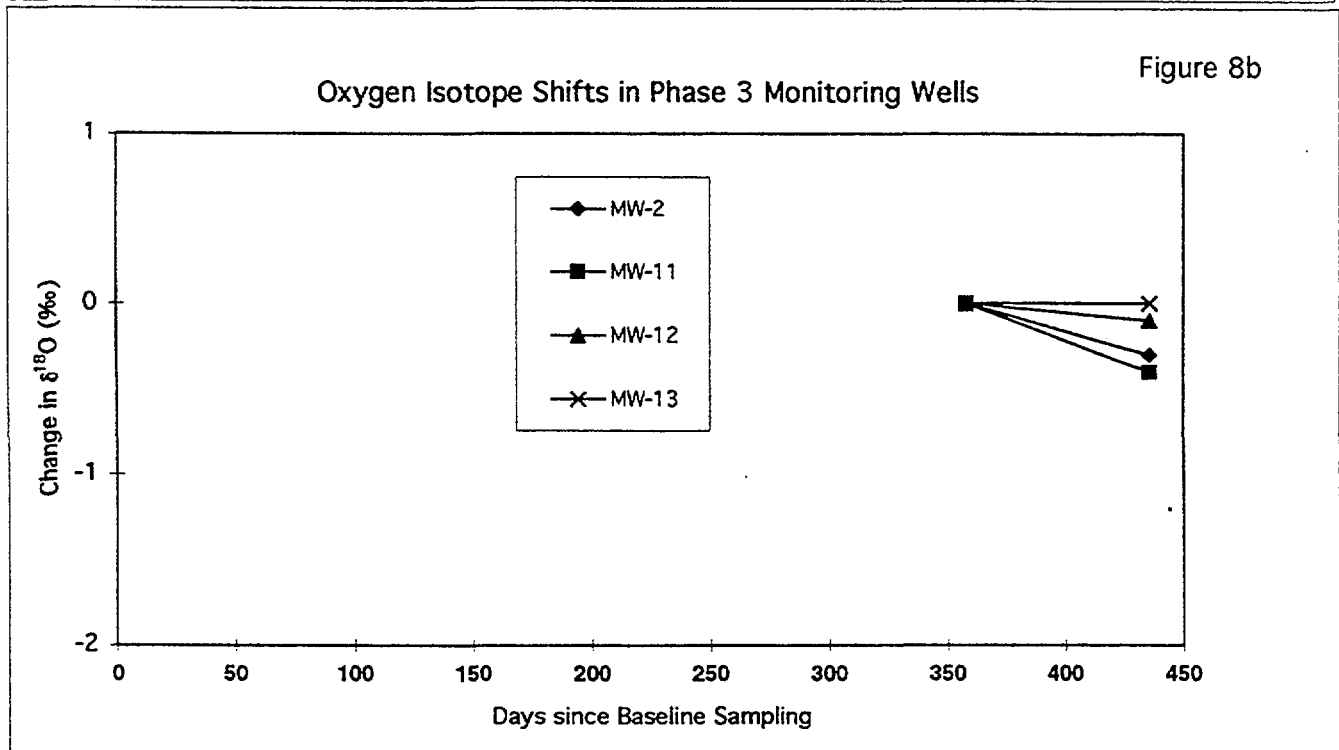
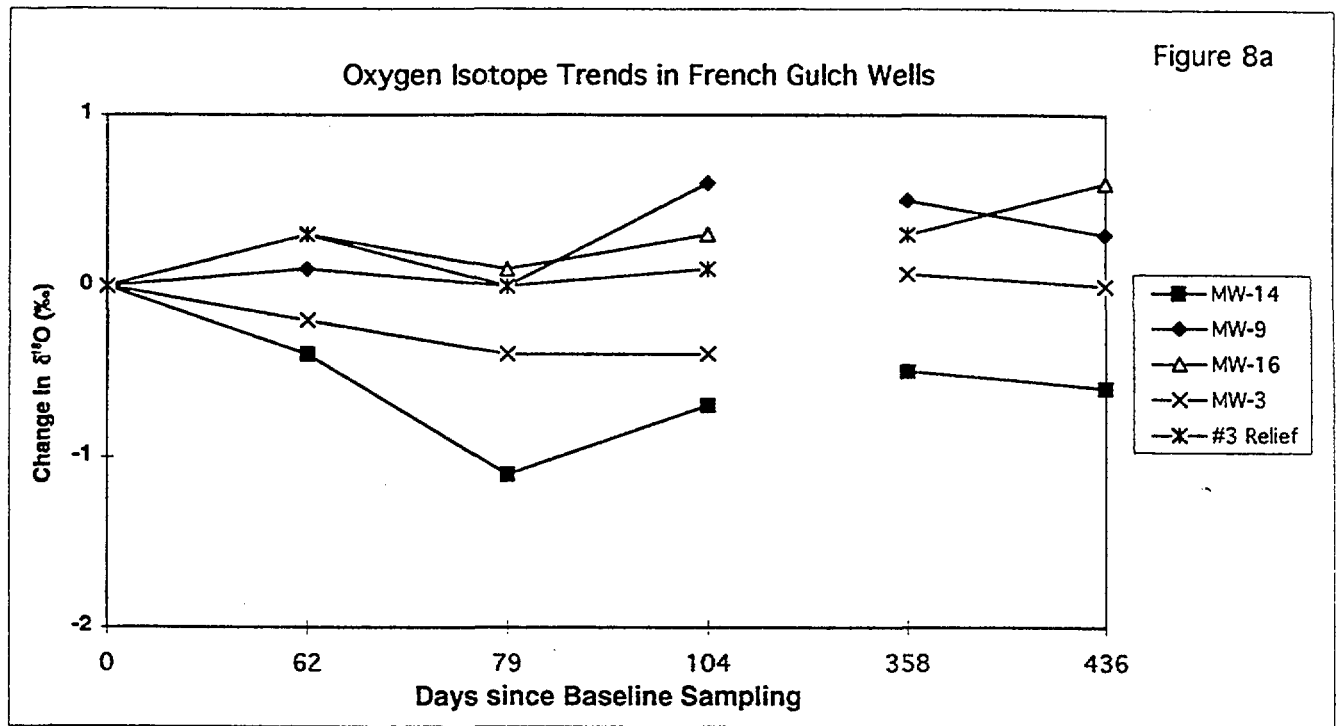
Figure 8a shows the relative changes in oxygen isotope composition of the five monitoring wells in French Gulch that were sampled throughout all Phases of the investigation. Three of these wells (MW-9, MW-16, and #3 Relief) exhibit either little change in oxygen isotopic signature, or a slightly more  $^{18}\text{O}$ -rich composition as the 1996 snowmelt progressed. This is incontrovertible evidence that the water level changes in these three wells in 1996 did not occur due to vertical infiltration or lateral migration of surface waters derived from melting low- $^{18}\text{O}$  snow. The water level rises in these wells are probably a response to increased lateral recharge from infiltration occurring somewhere upgradient from the wells. These wells appear to be largely isolated from the local surface in French Gulch, although two of them (MW-16, and #3 Relief) are contaminated with metals.

Figure 8b shows the relative changes in oxygen isotope composition of the four monitoring wells in French Gulch that were sampled only in Phase 3 of this investigation. One of these wells (MW-13) is contaminated with metals, but shows no change in stable isotopic composition between the March and late May, 1997 samplings. Again, this is an indication that the metals contamination does not arise from additions of metal-laden low- $^{18}\text{O}$  snowmelt. The remaining three Phase 3 wells (MW-2, MW-11, and MW-12) show slight downward shifts in  $\delta^{18}\text{O}$ , consistent with very minor additions of low- $^{18}\text{O}$  snowmelt during the Spring of 1997. Of these three wells only MW-2 is contaminated and this well shows the smallest shift in O-isotope ratio, again suggesting that low- $^{18}\text{O}$  snow is not involved as a contaminating agent.

### Evidence Supporting Surface Water Infiltration in Two French Gulch Monitoring Wells

Figure 8a also shows that two wells (MW-3 and MW-14) exhibit lower  $\delta^{18}\text{O}$  values after each of the snowmelt events. It is apparent, therefore, that rising water levels in these two wells were caused, at least in part, by local infiltration of low- $^{18}\text{O}$  snowmelt from the surface. Note that MW-3 is a contaminated alluvial well and the alluvial aquifer in this area may be in hydrologic communication with the surface. In the same sense, MW-14 is an uncontaminated well drilled along a fault which may provide a rapid transport pathway between the surface and the shale aquifer at that site.

Because these two wells exhibit lower  $\delta^{18}\text{O}$  values during high water level conditions, it is possible to model the processes responsible for water level rise and aquifer contamination at these two sites. Figures 9a and 9b show the relative changes in oxygen isotope composition and water level for monitoring wells MW-14 and MW-3, respectively. In the first 60 days after the Baseline sampling, both wells showed rises in water level as well as negative shifts in  $\delta^{18}\text{O}$  value. In the ensuing 17 days, water levels began to decline while  $\delta^{18}\text{O}$  values continued their downward shifts.



In the final 25 days of Phase 2, between the third and fourth samplings, water levels continued to decline while  $\delta^{18}\text{O}$  values remained stable or reversed to slightly higher  $\delta^{18}\text{O}$  compositions. The patterns displayed on Figures 9a and 9b are remarkably similar and suggest the following:

- During the initial 60 days, the rising water levels could be the result of a combination of higher rates of lateral recharge and infiltration of small amounts of low- $^{18}\text{O}$  snowmelt from the surface.
- During the ensuing 17 days, recharge from low- $^{18}\text{O}$  surface waters (snowmelt) continued, while lateral recharge declined.
- During the final 25 days, both surface and groundwater recharge continued to decline.

Note that the first part of the pattern is repeated in 1997 for each of these wells, although the O-isotopic compositions of the waters changed from mid-winter in 1996 to mid-winter in 1997, another indication of the open system behavior of these two wells.

### Evidence Supporting Surface Water Involvement in Metals Contamination at MW-14

Figure 10a shows that Zinc concentrations in monitoring well MW-14 rose from their Baseline values through the first 62 days since the Baseline sampling, while water levels were rising and low- $^{18}\text{O}$  snowmelt was being added to the aquifer by infiltration from above. In the ensuing 17 days, however, Zinc concentrations continued to rise while the water level was falling. Note that the  $\delta^{18}\text{O}$  value was continuing to fall, suggesting that contaminated snowmelt or another relatively low- $^{18}\text{O}$  source may be responsible for the Zinc contamination in this well.

### Evidence against Surface Water Involvement in Metals Contamination at MW-3

In contrast to MW-14, Figure 10b shows a strong correlation between water level and Zinc concentration in monitoring well MW-3. In this case, Zinc concentrations began to fall between days 62 and 79, despite the continued decreases in the  $\delta^{18}\text{O}$  value of the water. This suggests that the Zinc contamination originates predominantly through subsurface interactions between groundwater and sulfide-rich rocks at this site, despite the proximity to mill tailings at the surface.

### Stable Isotopic Compositions of Mine Waters in French Gulch

Throughout this report, we have emphasized that most of the contaminated waters in French Gulch have stable isotopic compositions similar to local groundwater. Only two monitoring wells (MW-3 and MW-14) show consistent stable isotopic evidence of surface water infiltration. Kenny Dog Springs also showed evidence of considerable snowmelt contamination in the Baseline sampling, but has since been isotopically similar to local groundwater. Figure 11 shows the oxygen and hydrogen isotopic compositions of mine waters collected at a variety of depths ranging from 1345 to 1610 feet. Some of the data points lie to the right and below the Global Meteoric Water Line (MWL), suggesting a history of some evaporation. The stable isotopic compositions of the mine waters are similar to those of local groundwaters, such that mine waters could be implicated in the contamination found in French Creek. Figure 11 shows that the two deepest samples (1530 and 1610 ft) are somewhat richer in  $^{18}\text{O}$  and D than shallower samples, indicating that the mine waters originated at different times and that they are not well mixed over short time spans. If this is the case, then it may be possible to isolate portions of the mine that are in current communication with the Creek, leaving already isolated regions of the mine alone. This would, of course, greatly reduce the overall costs of remediating the contamination problems in the area.

## **Appendix 1**

### **Time Series Plots for French Gulch Samples**

## **Appendix 2**

### **Data Reports for Stable Isotope Analyses**

## **Appendix 3**

### **Data Reports for Metals Analyses**

Figure 9a

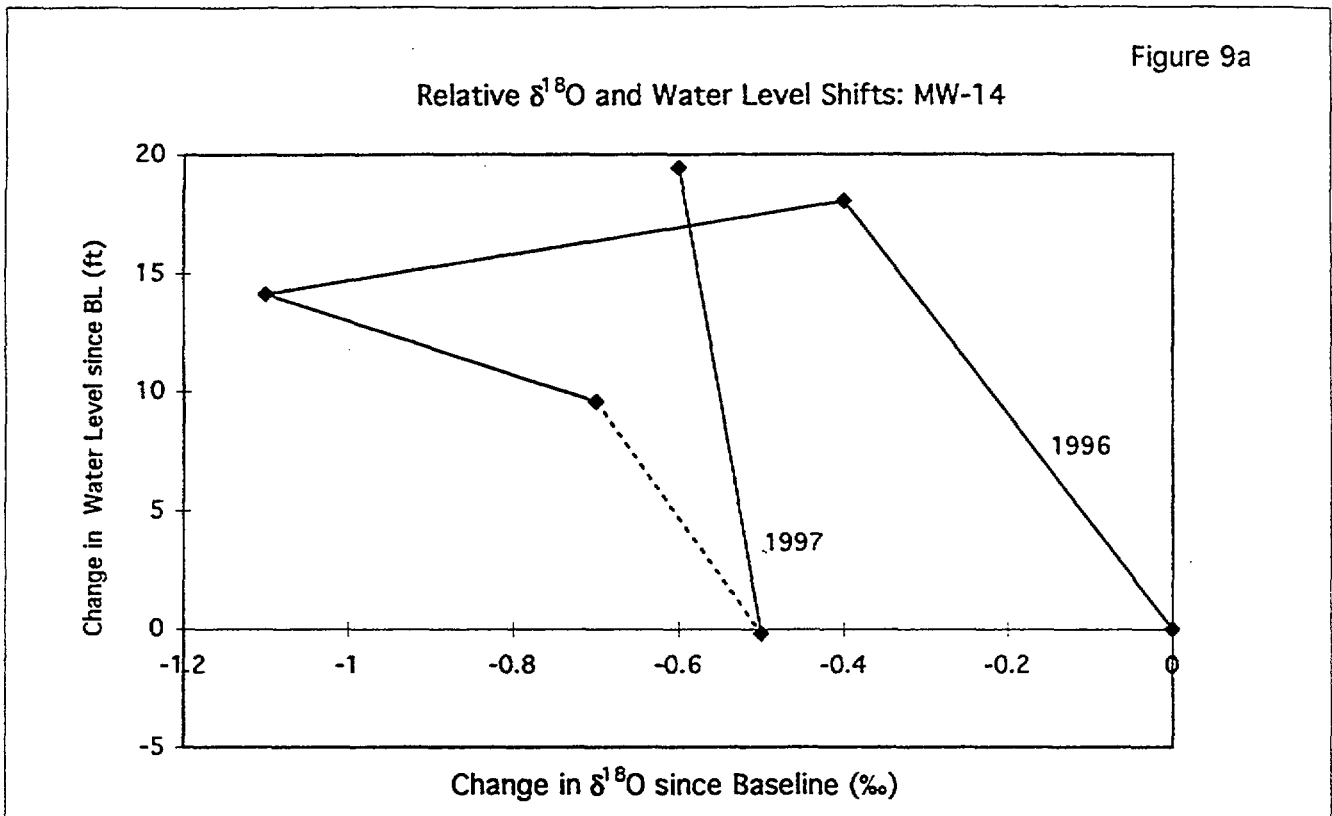
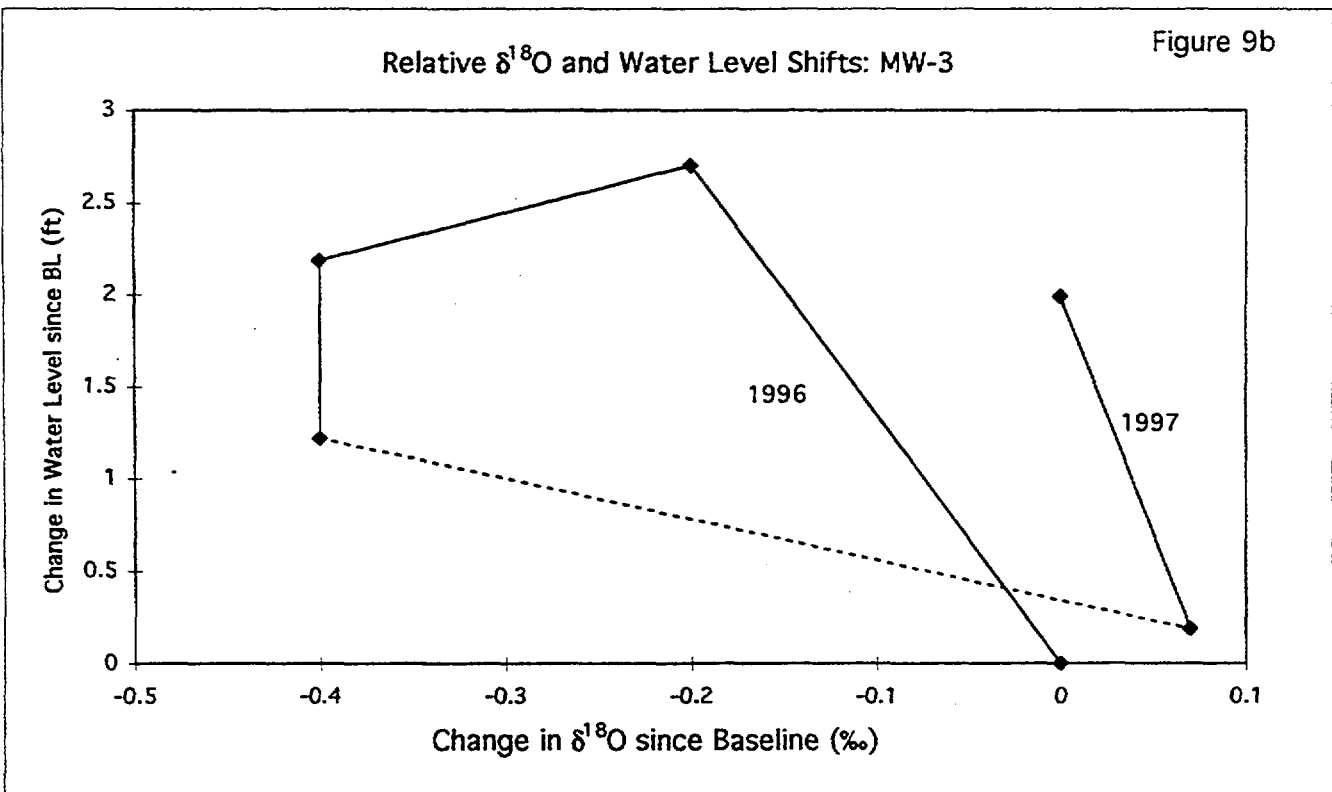
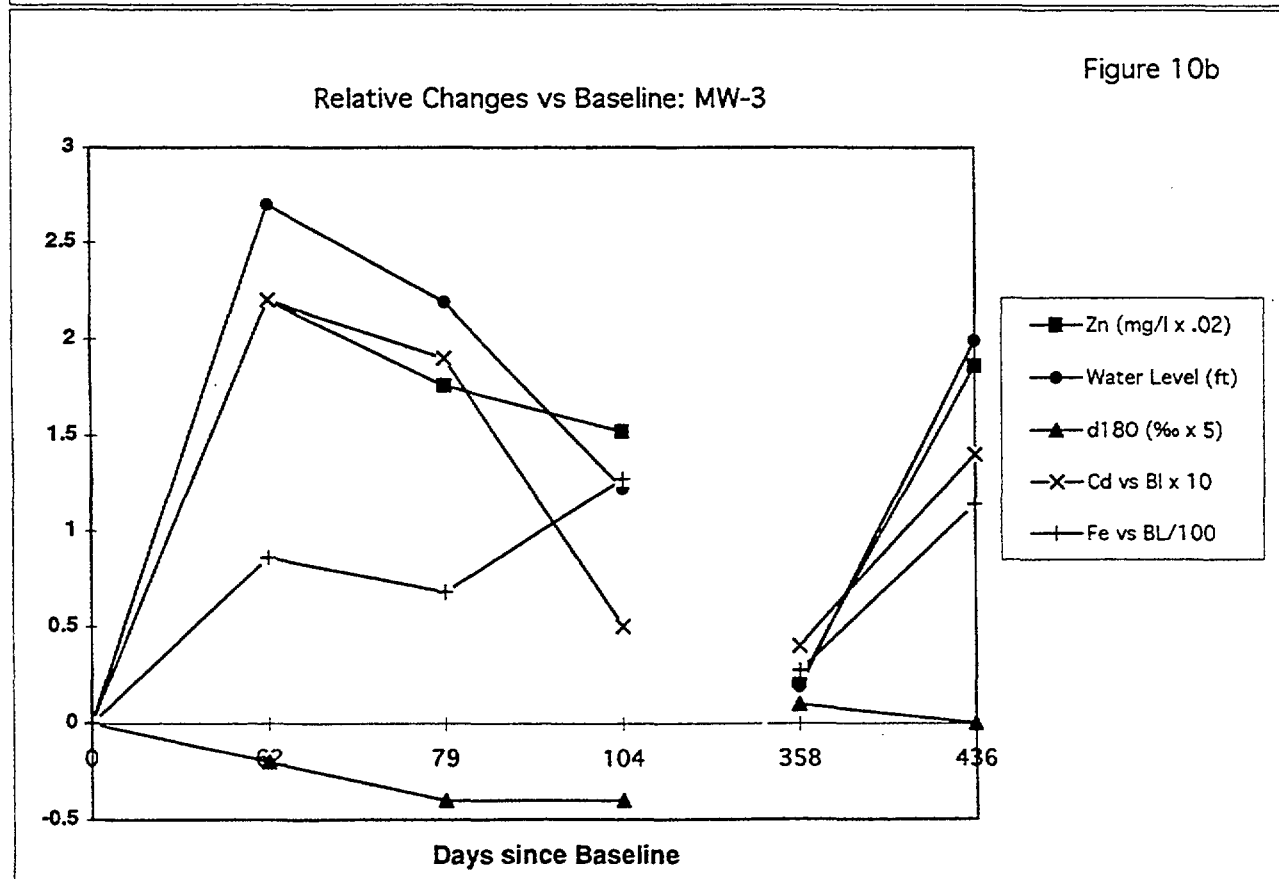
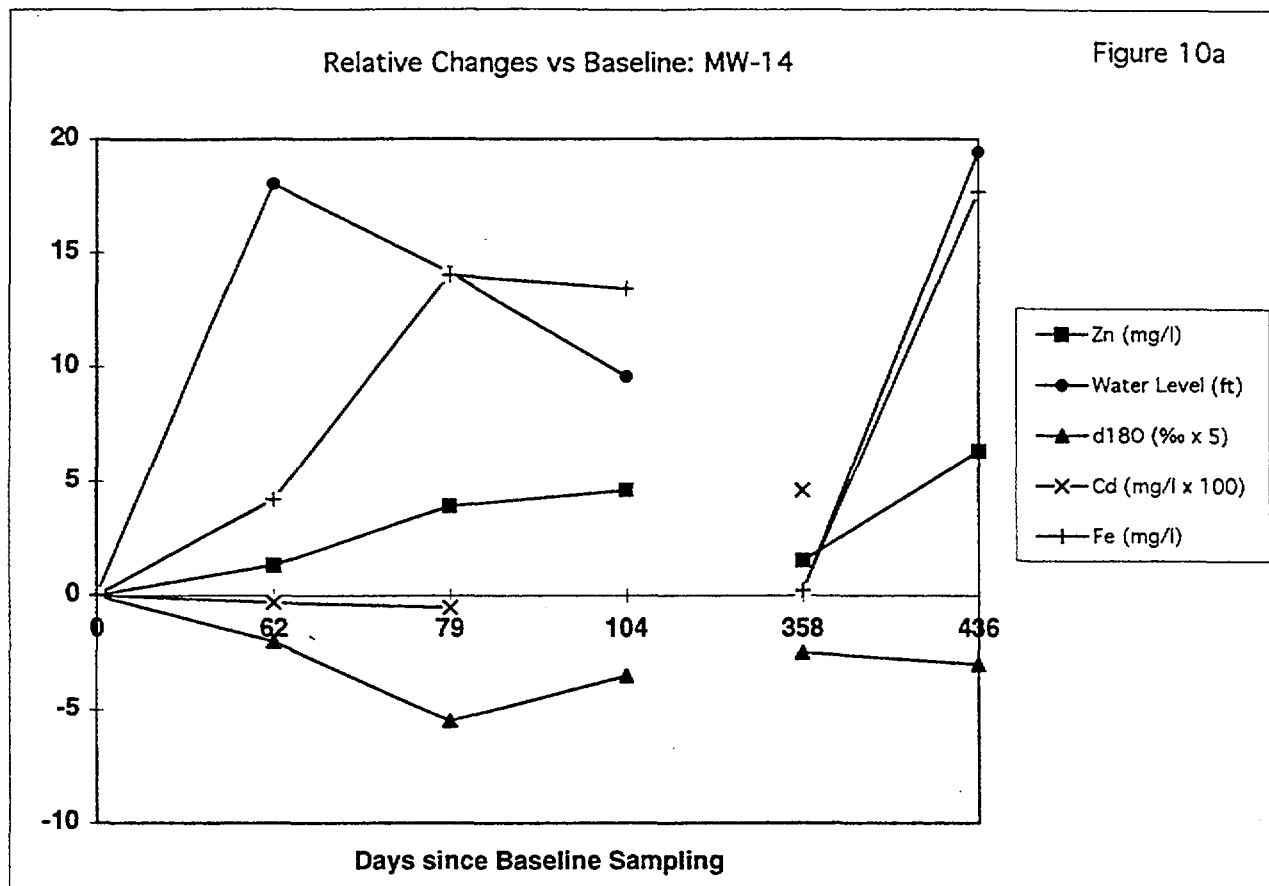
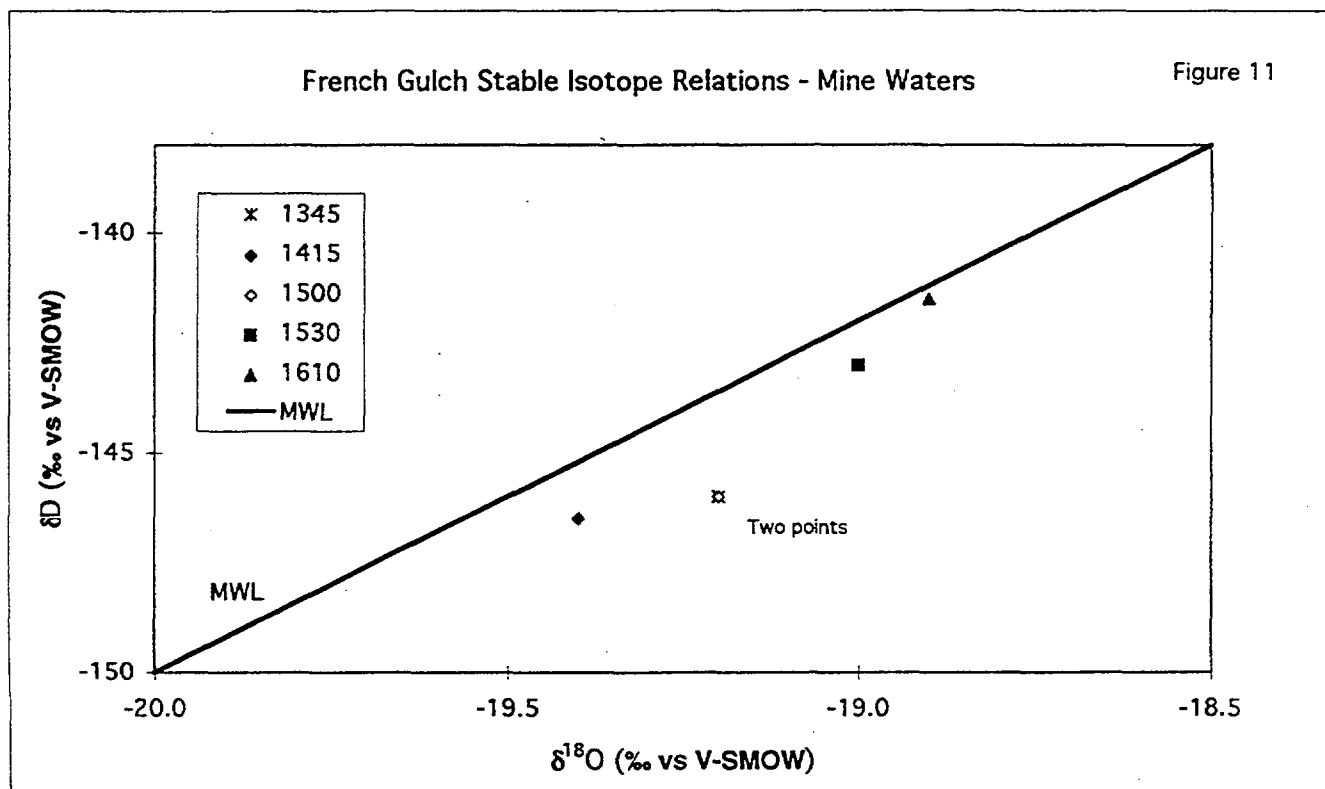


Figure 9b



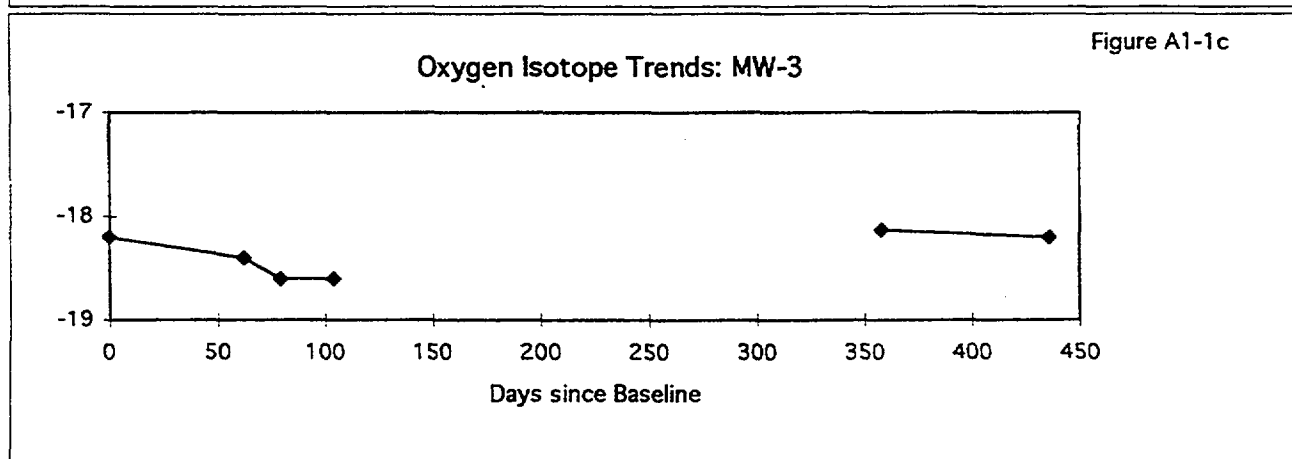
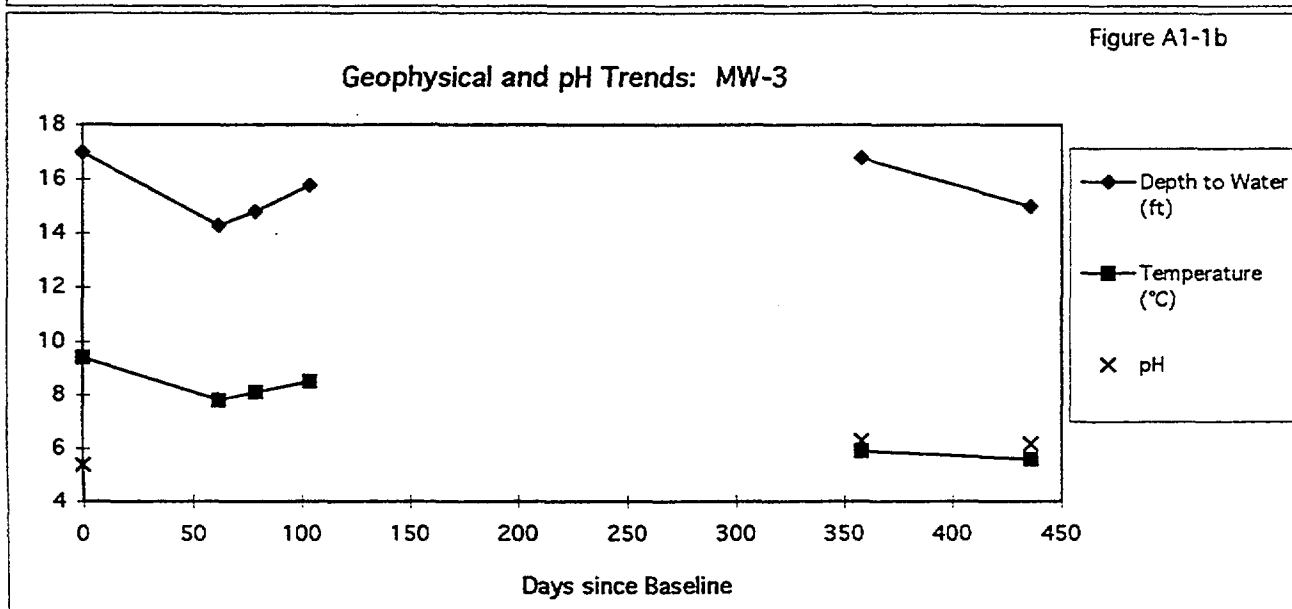
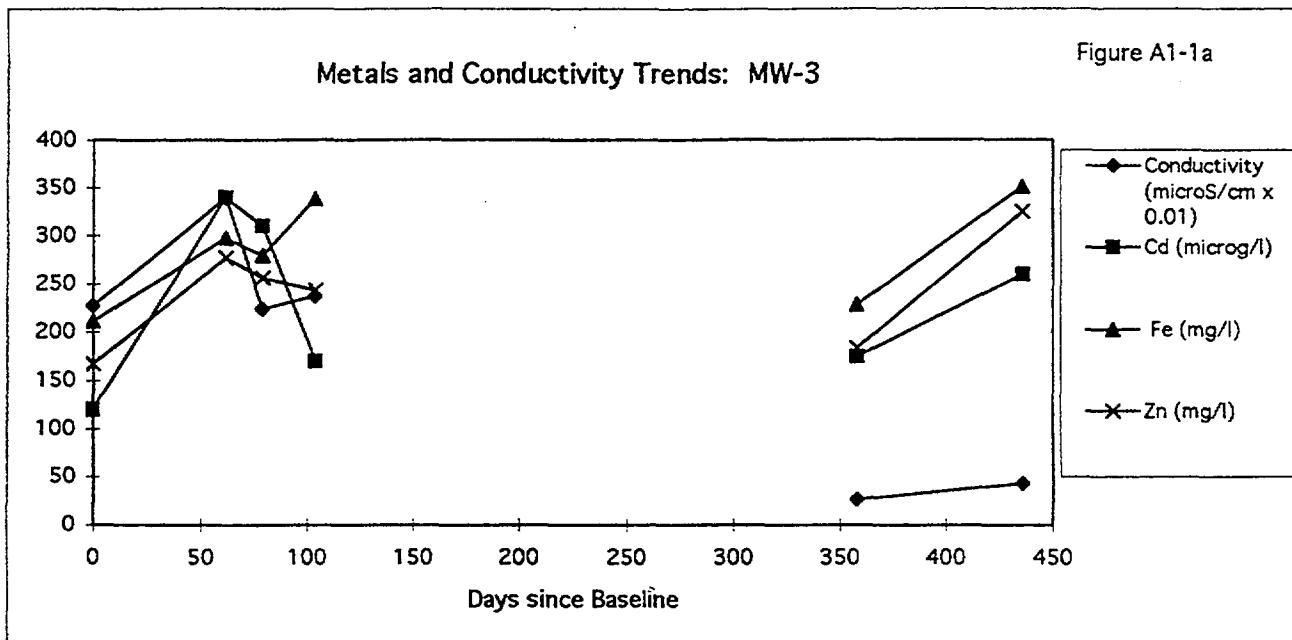


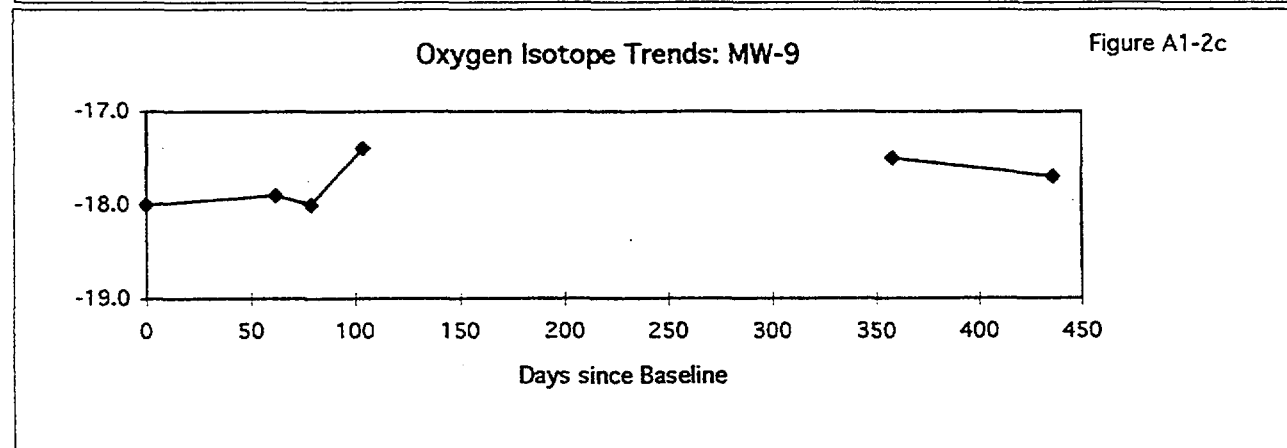
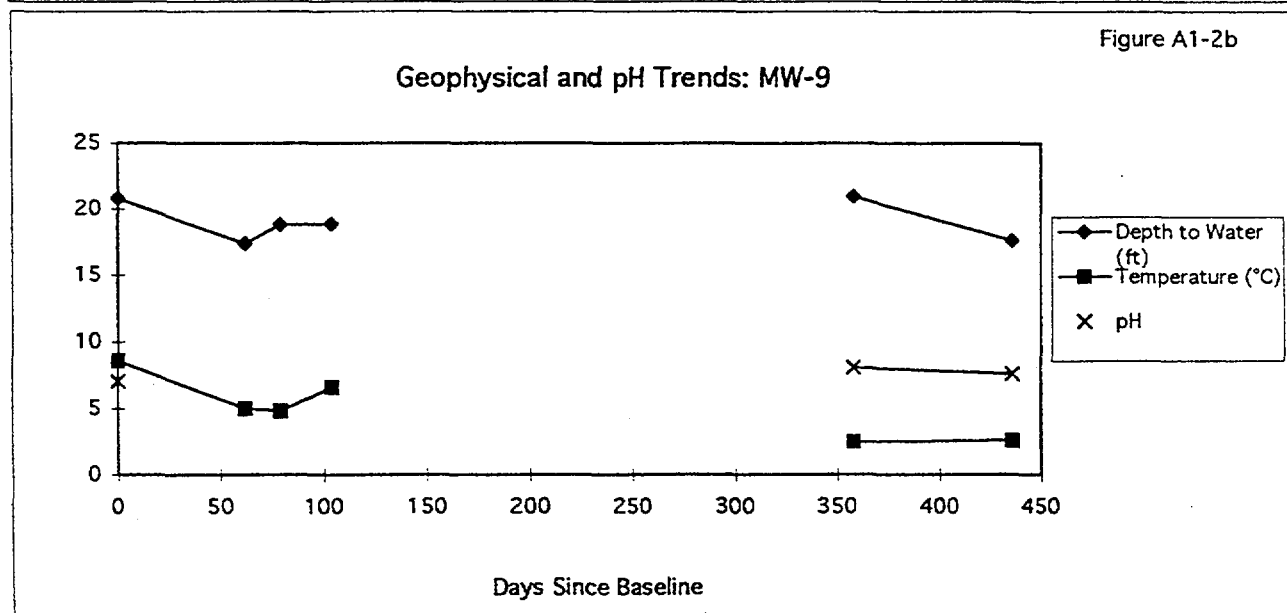
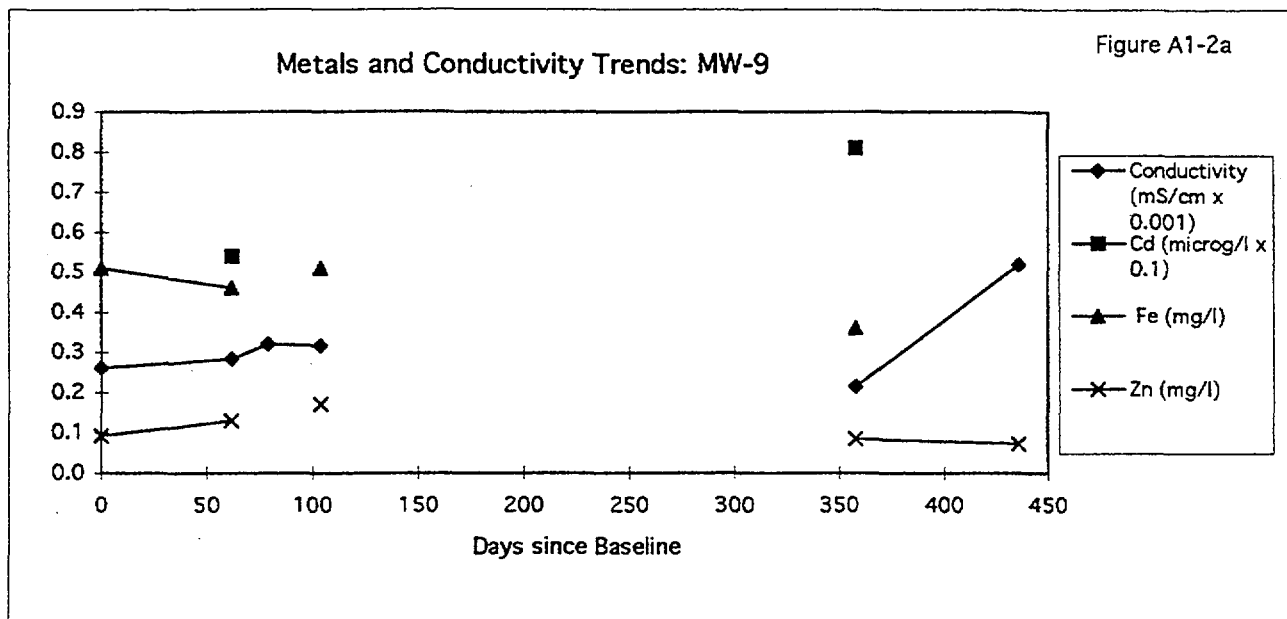




## **Appendix 1**

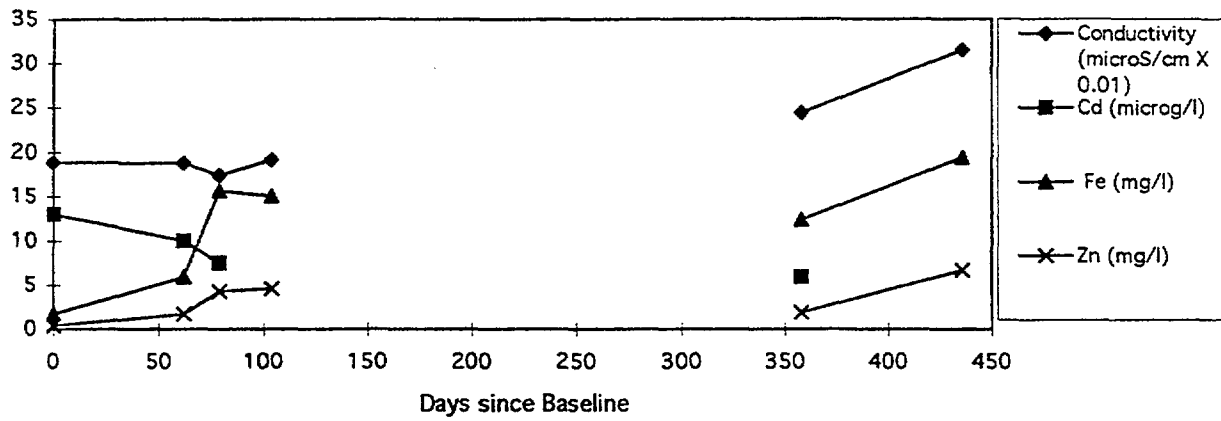
### **Time Series Plots for French Gulch Samples**





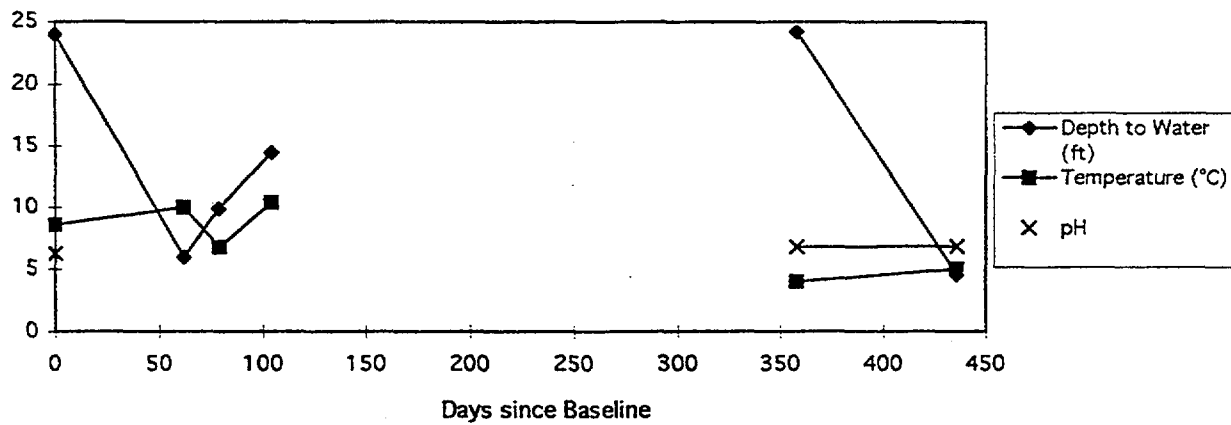
Metals and Conductivity Trends: MW-14

Figure A1-3a



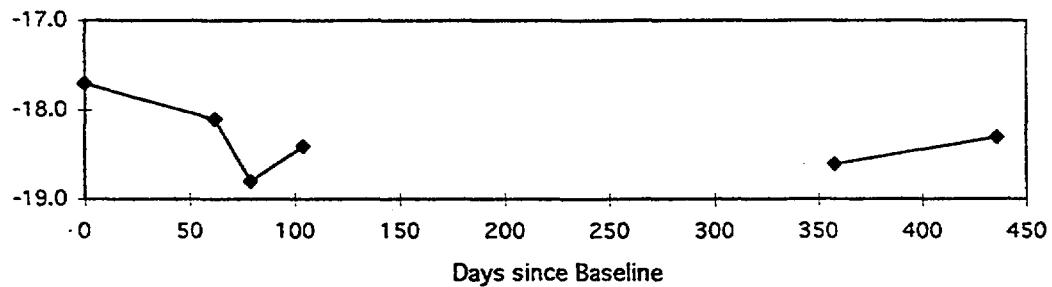
Geophysical and pH Trends: MW-14

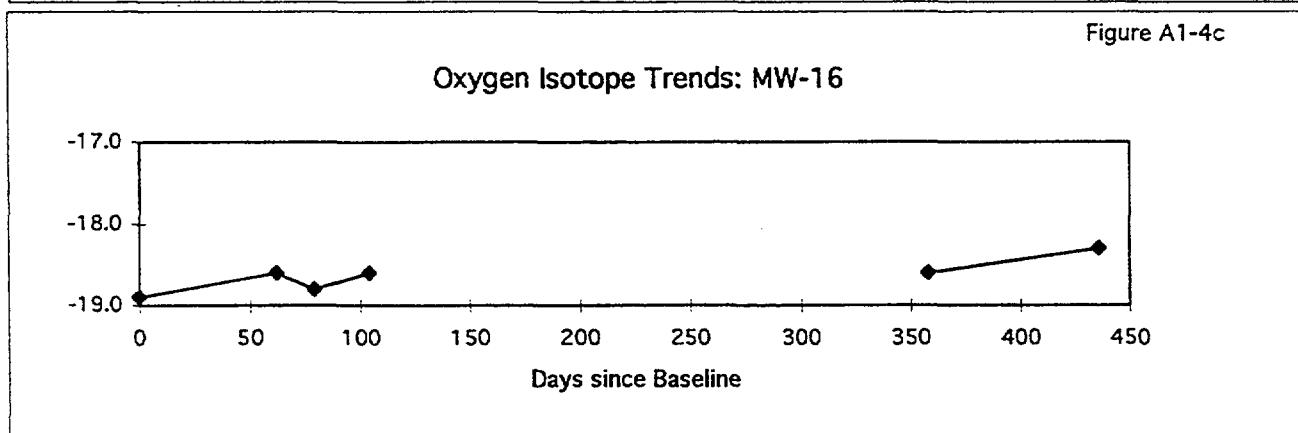
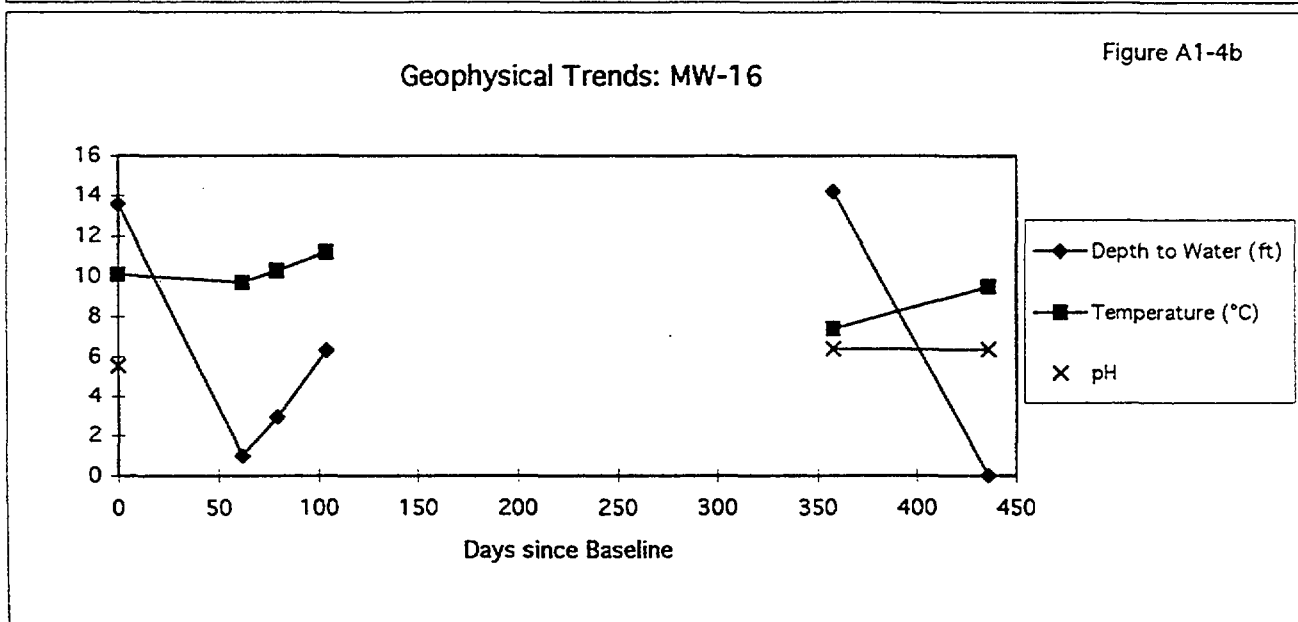
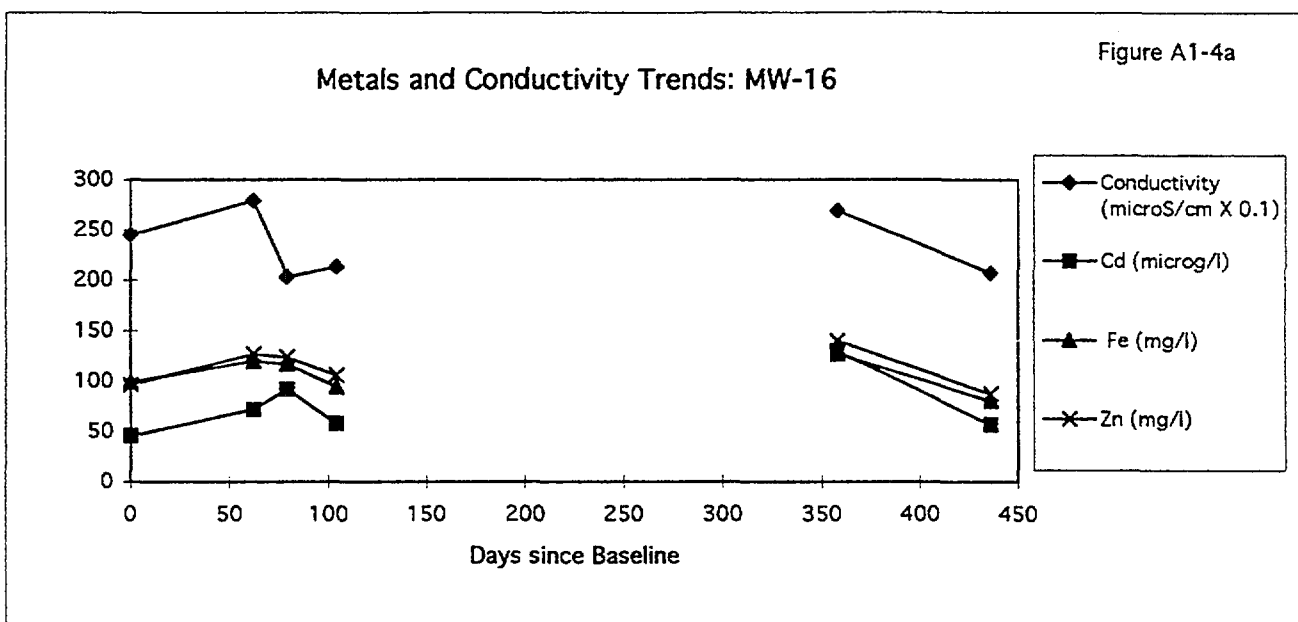
Figure A1-3b

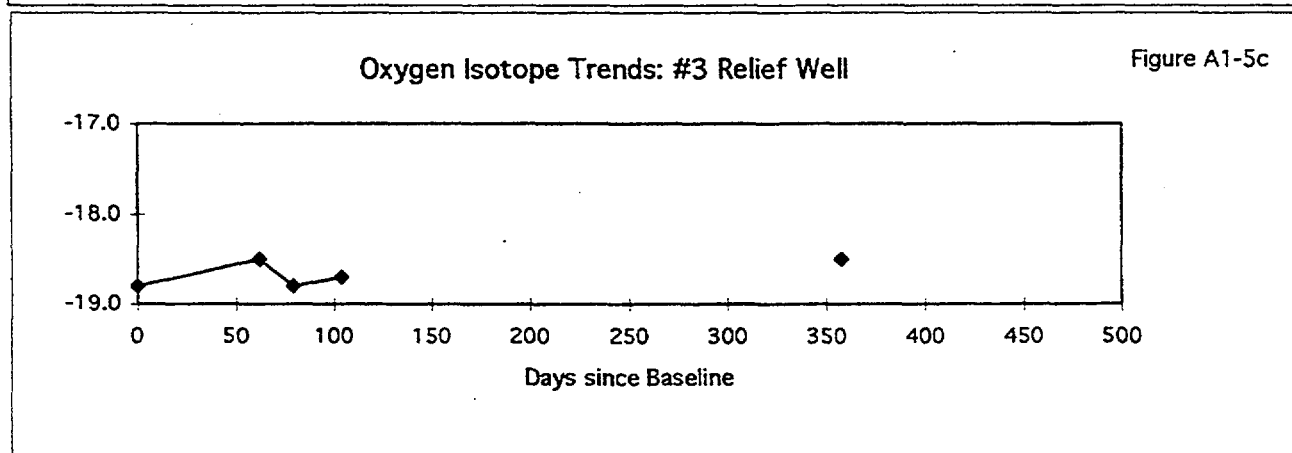
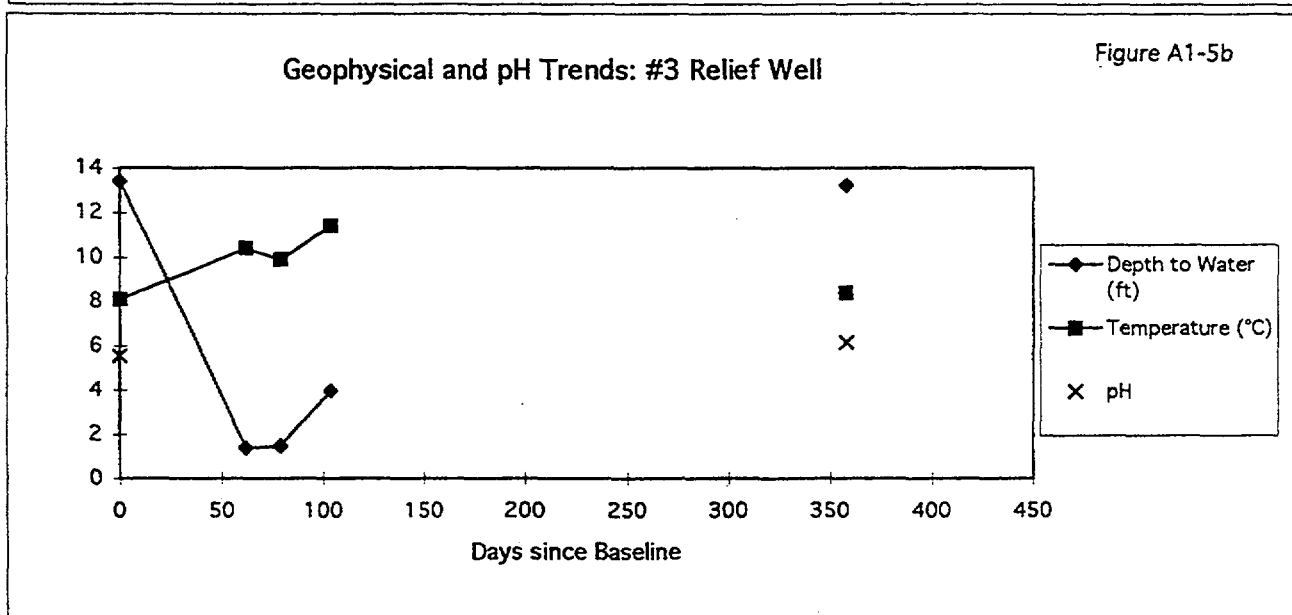
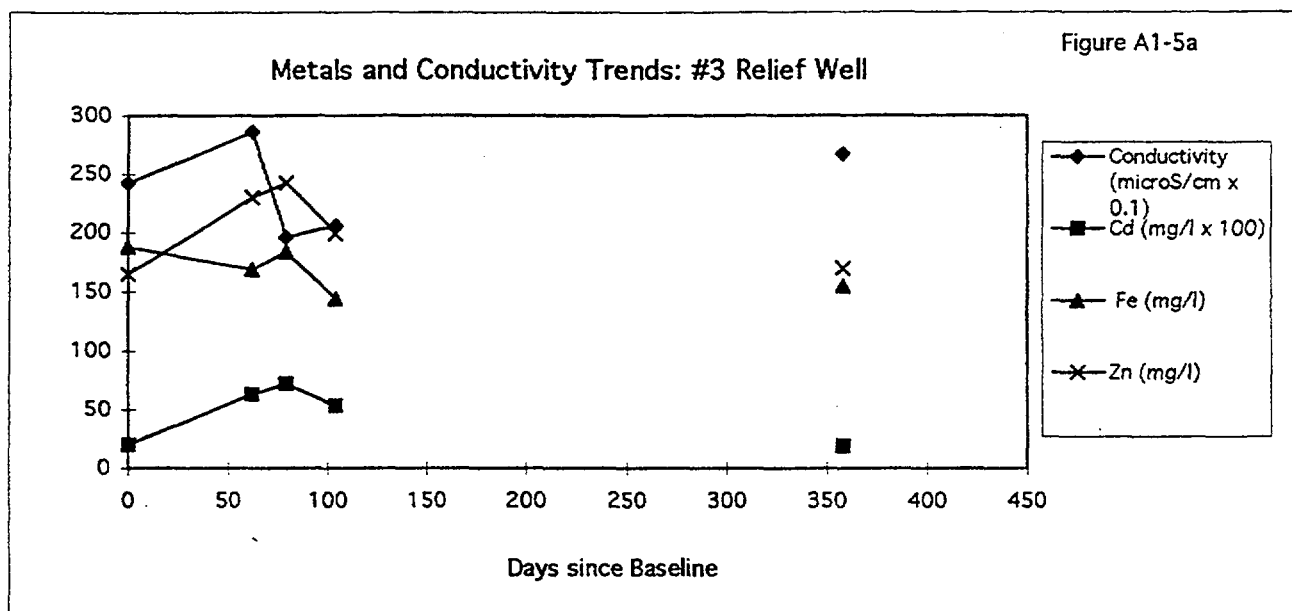


Oxygen Isotope Trends: MW-14

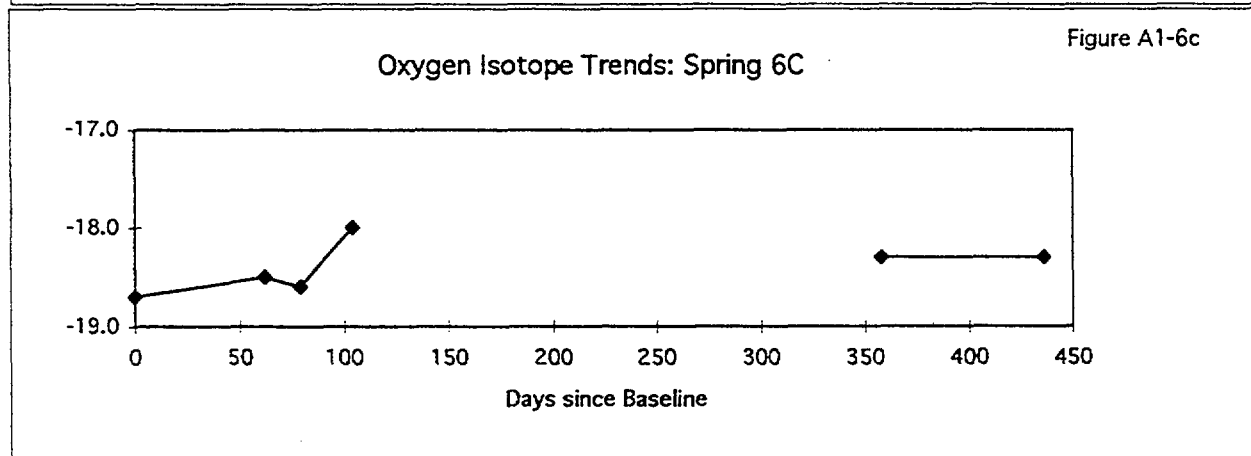
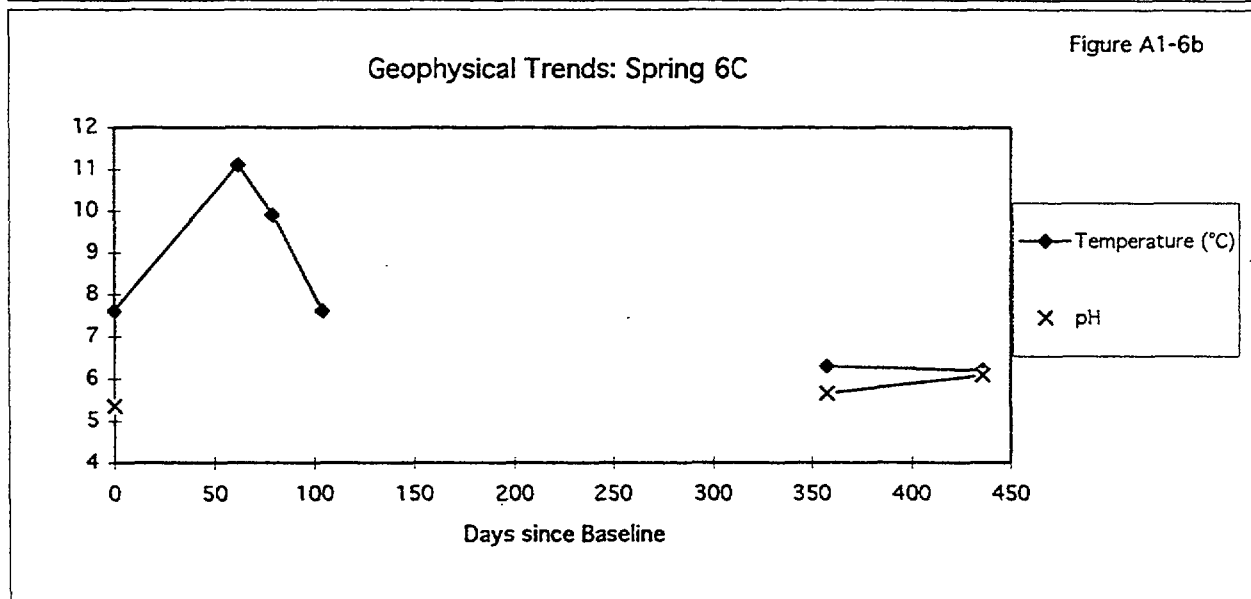
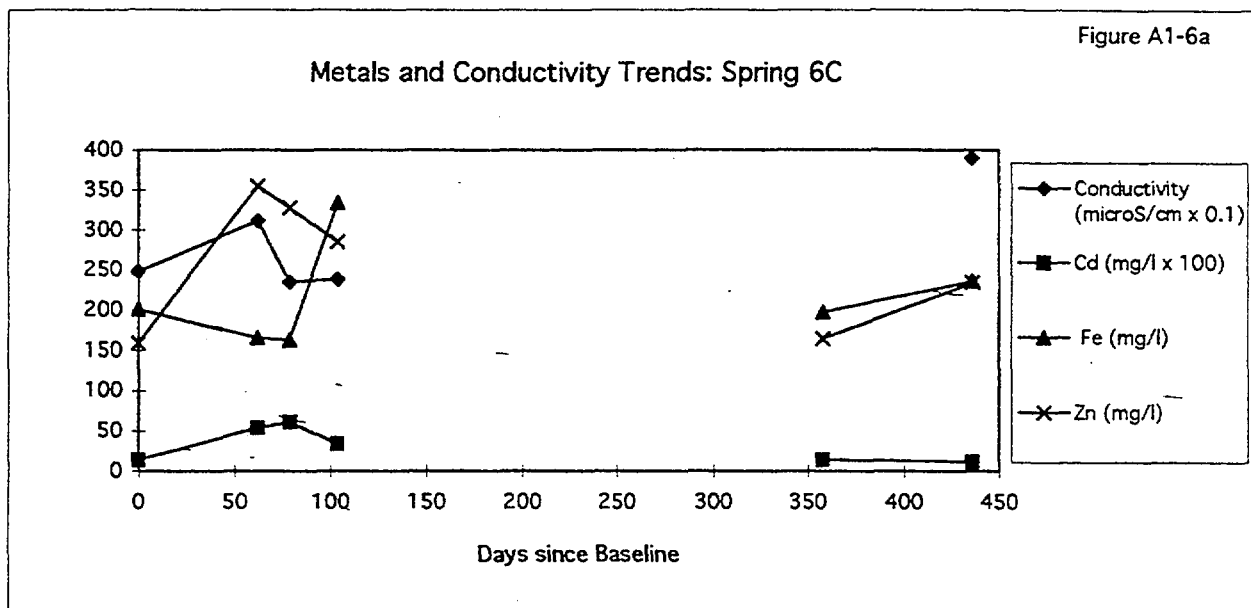
Figure A1-3c





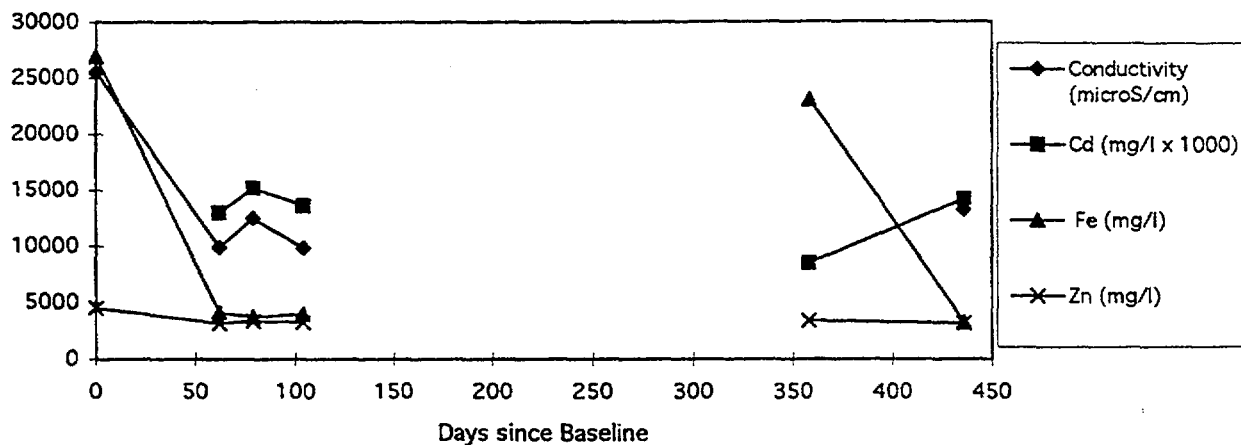






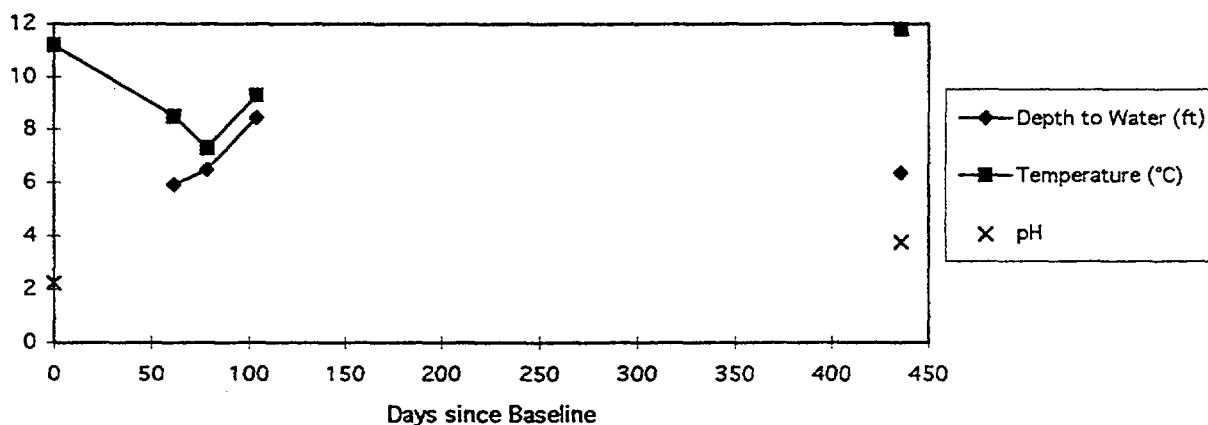
Metals and Conductivity Trends: Roaster Fines #3

Figure A1-7a



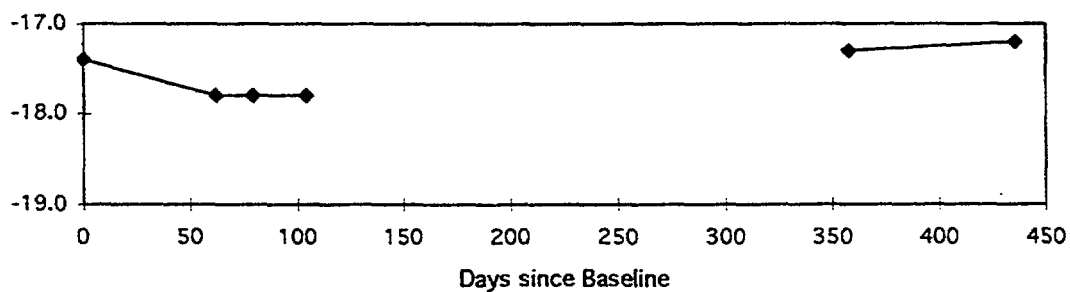
Geophysical Trends: Roaster Fines #3

Figure A1-7b



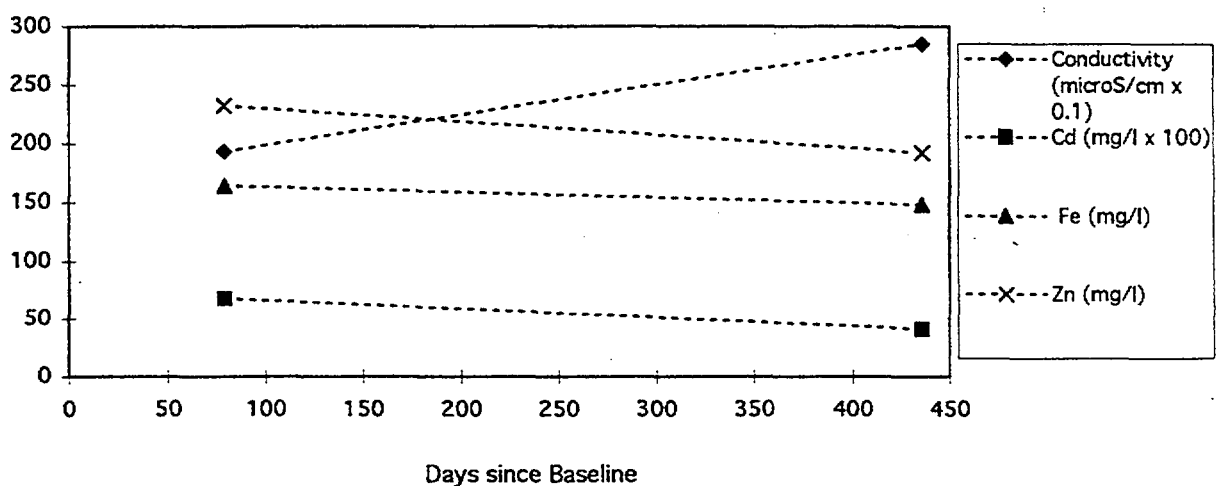
Oxygen Isotope Trends: Roaster Fines #3

Figure A1-7c



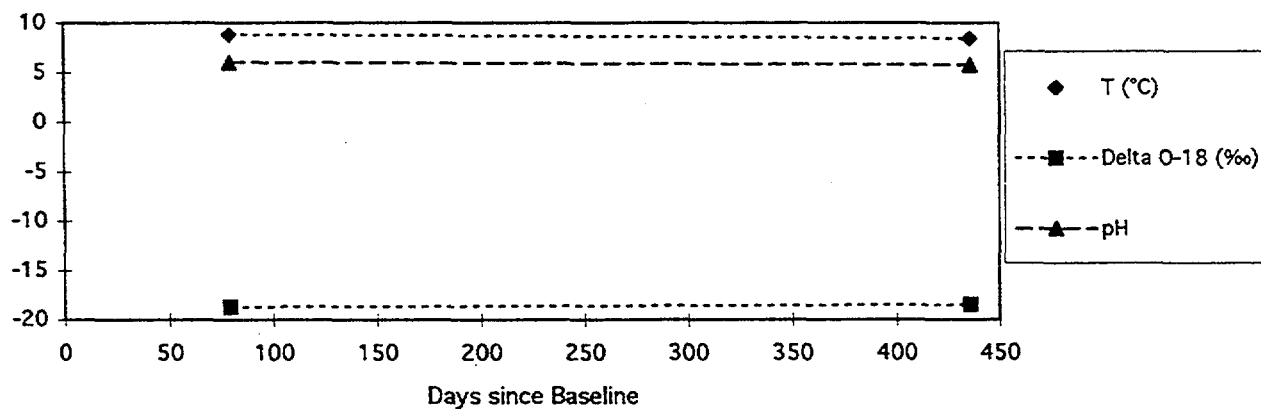
Metals and Conductivity Data: #3 Mine Water

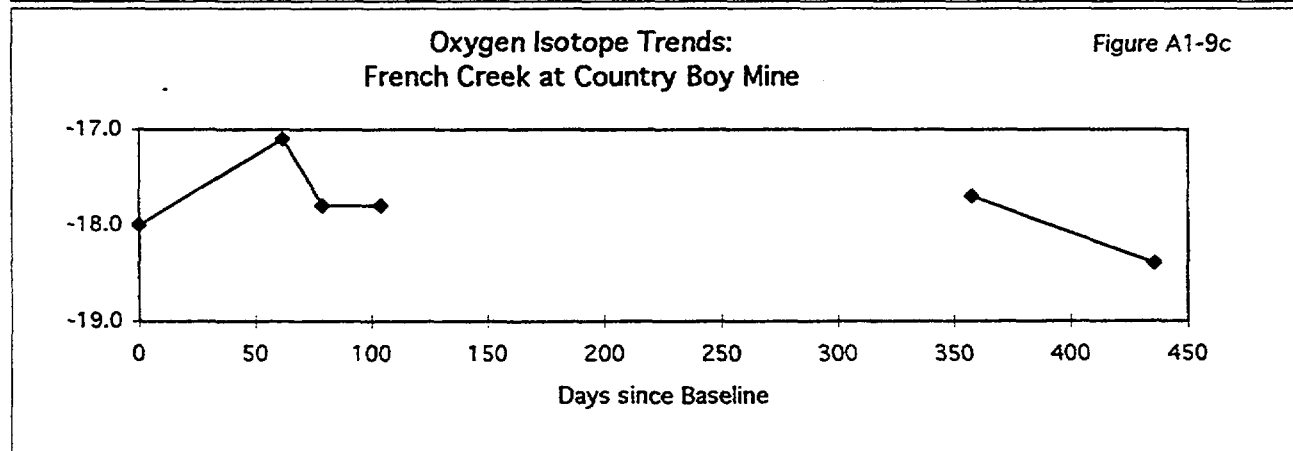
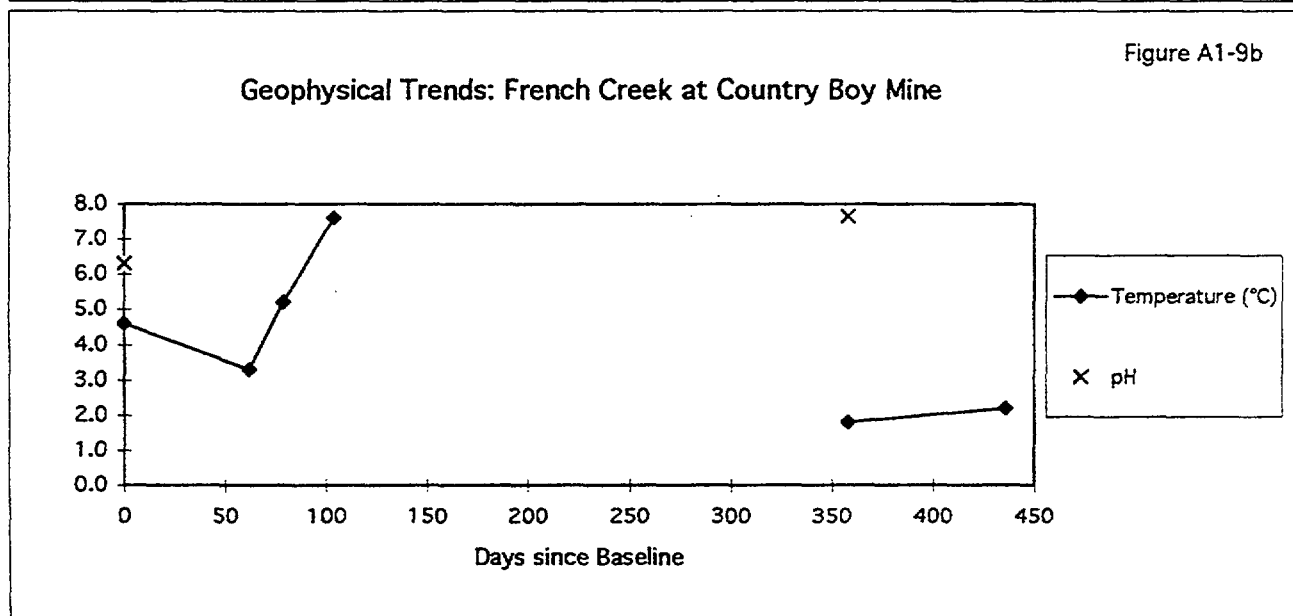
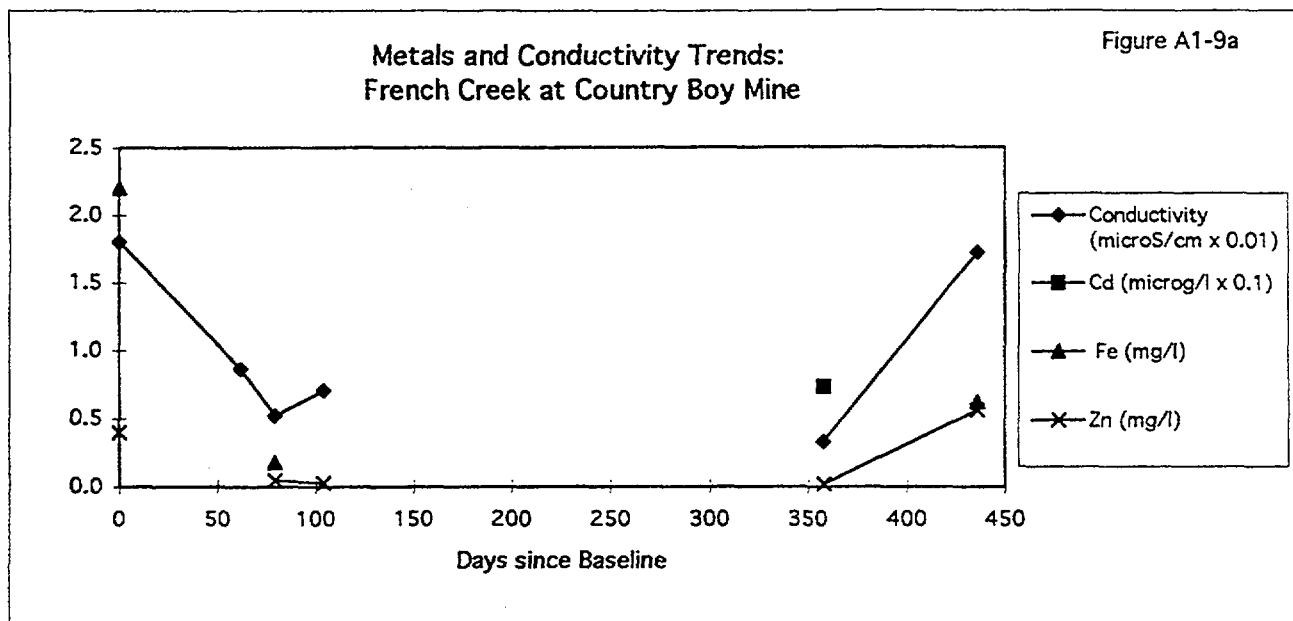
Figure A1-8a

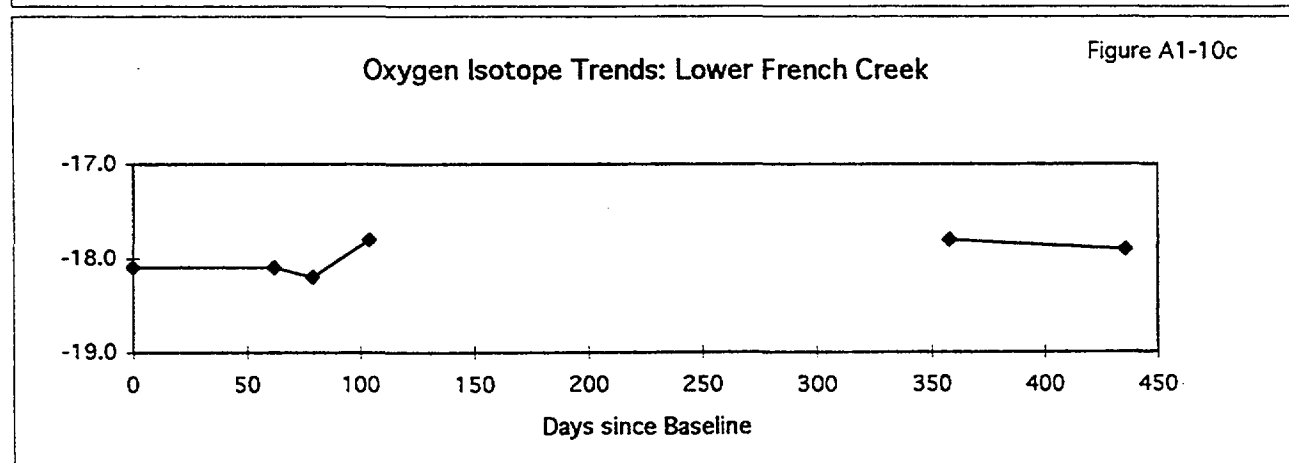
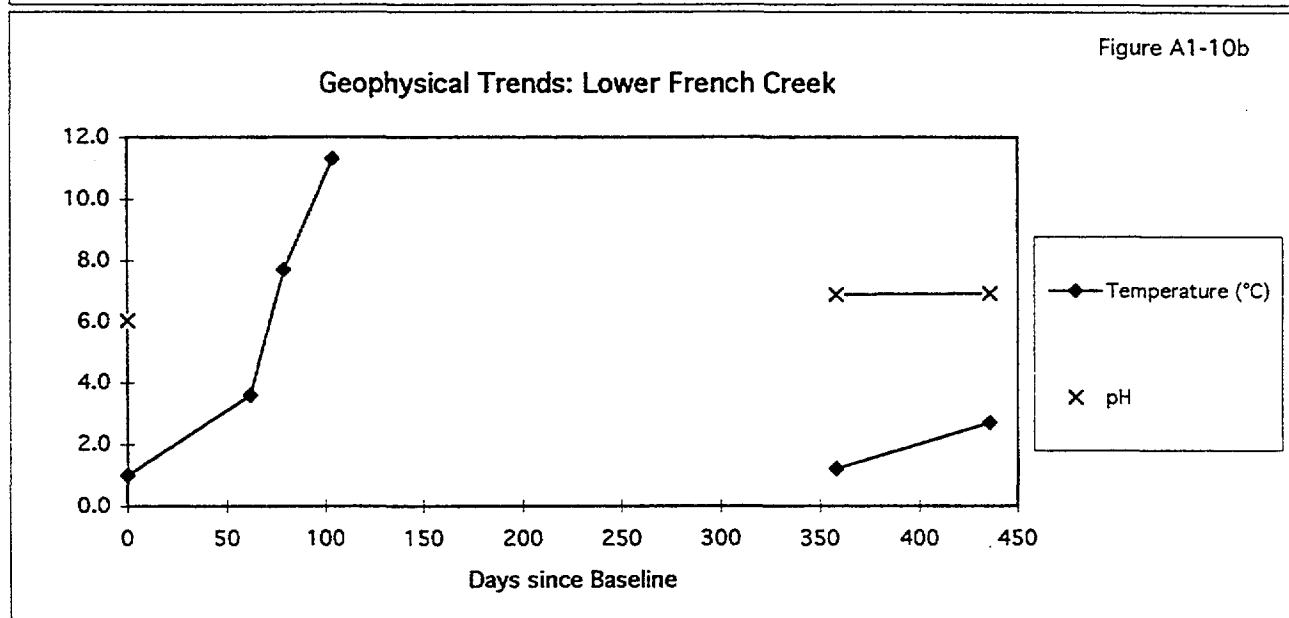
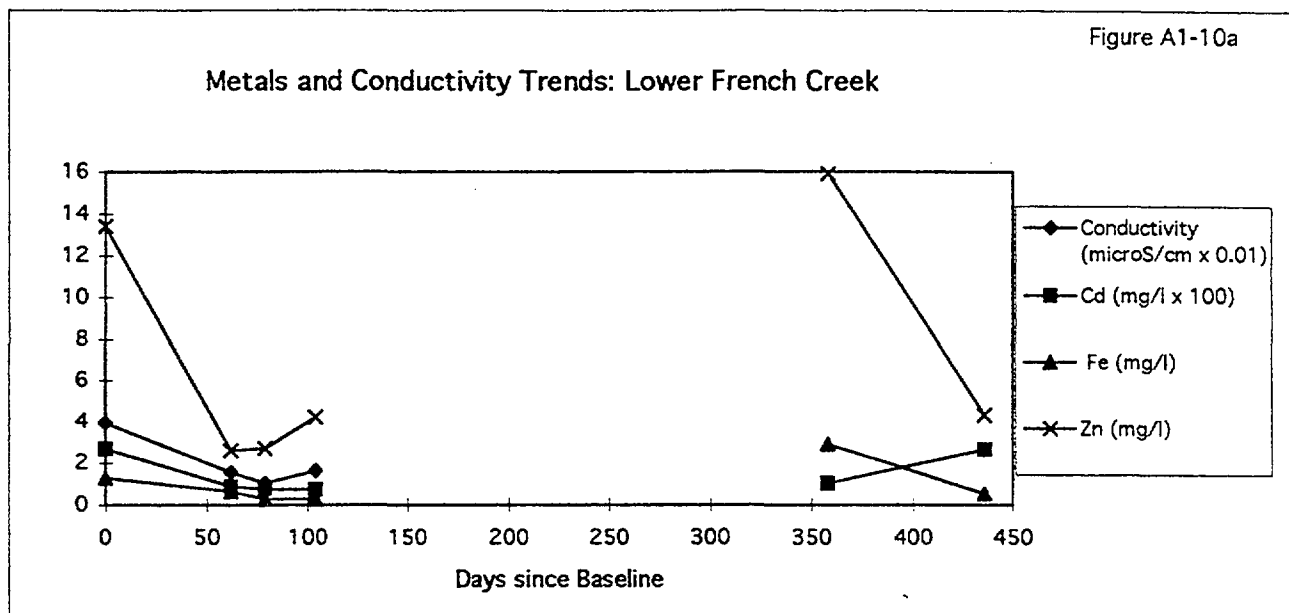


Temperature, pH, and O-isotope Data, #3 Mine Water

Figure A1-8b

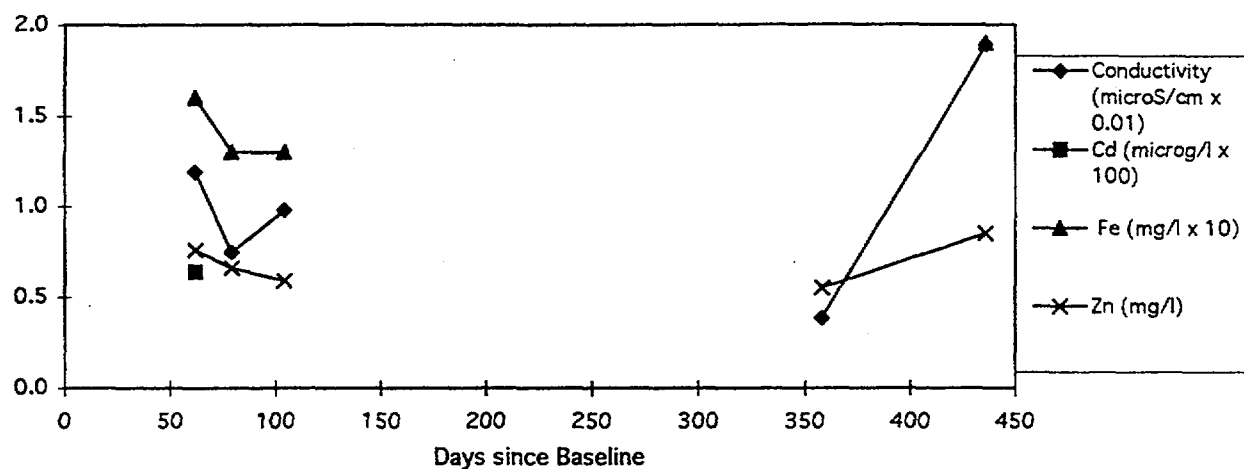






Metals and Conductivity Trends:  
French Creek at Dead Elk Pond

Figure A1-11a



## Geophysical Trends: French Creek at Dead Elk Pond

Figure A1-11b

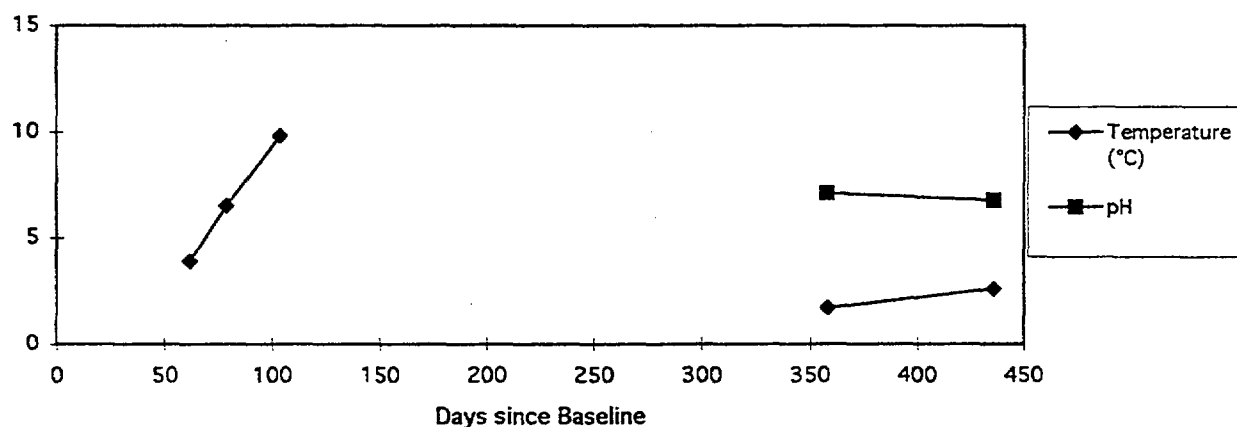
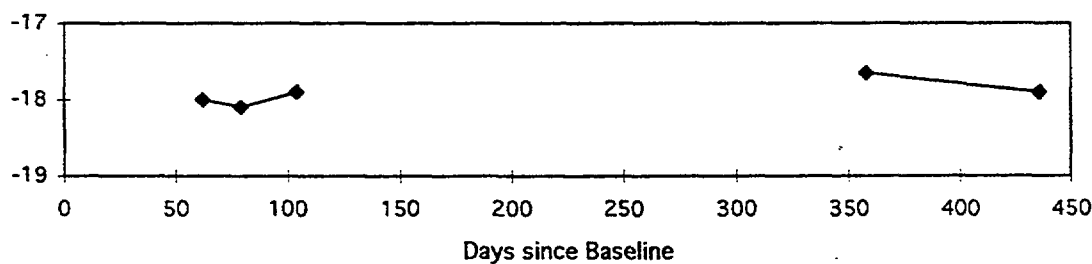
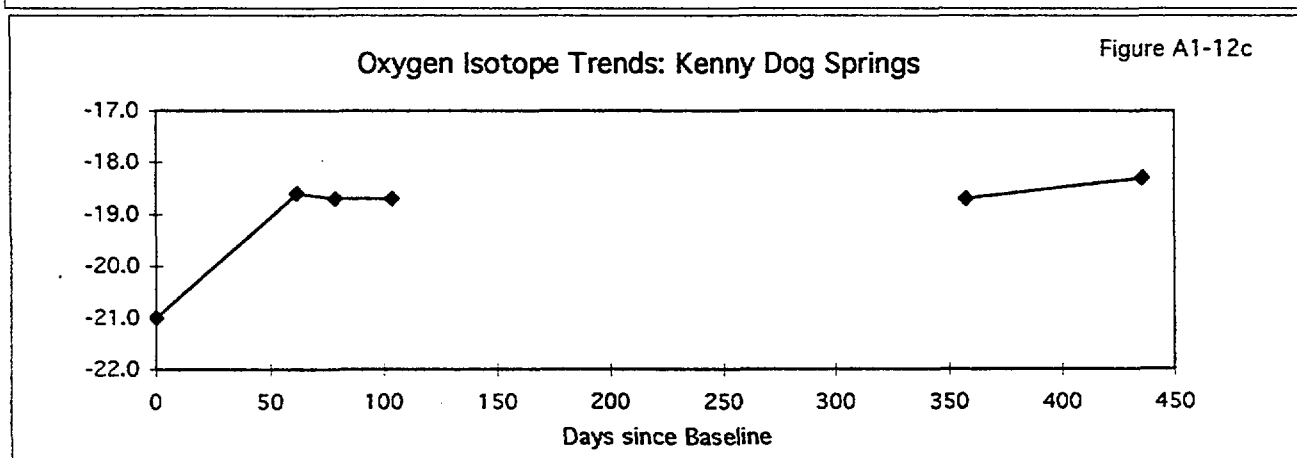
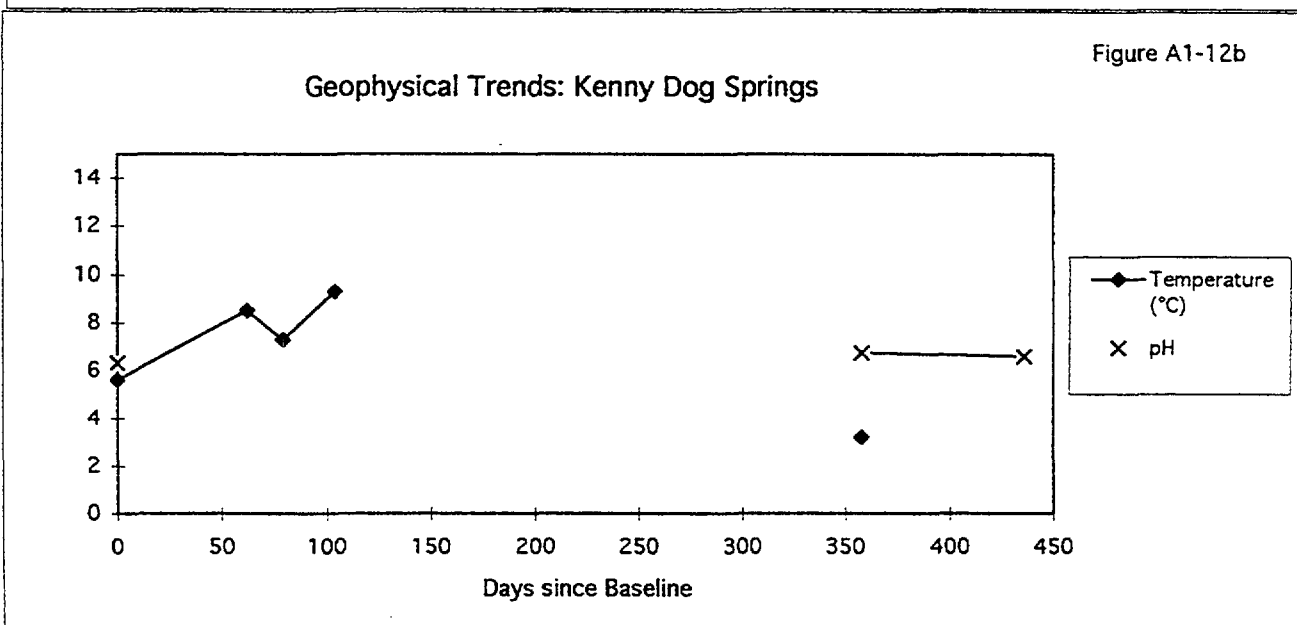
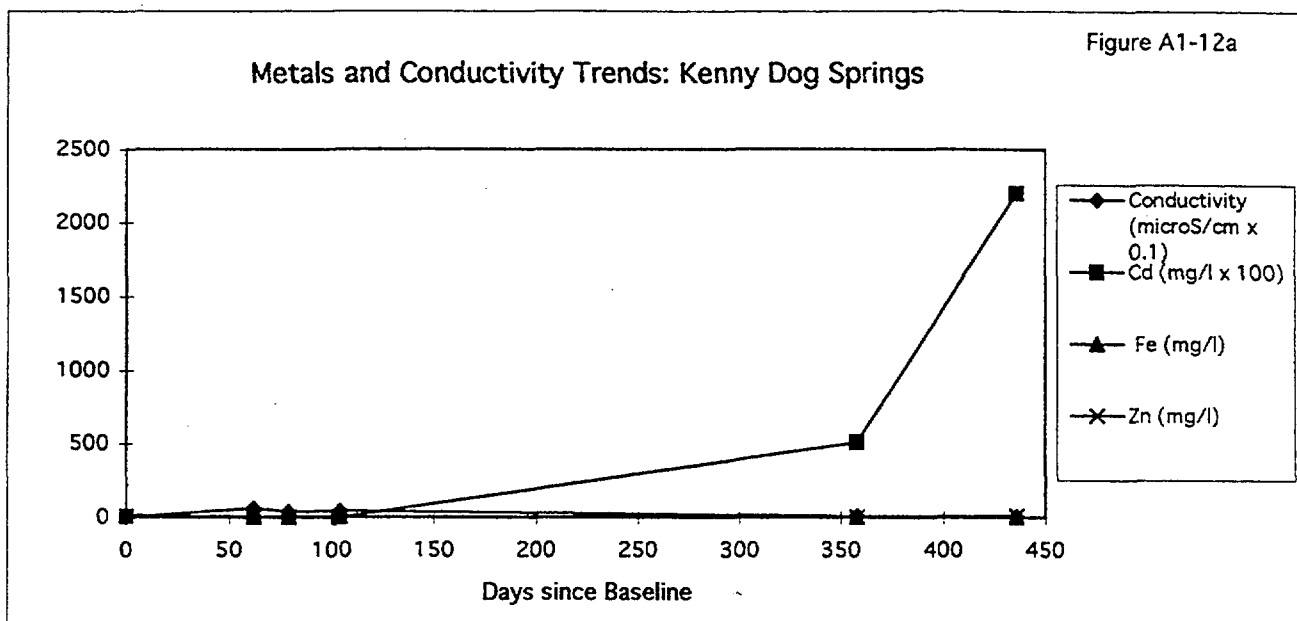
Oxygen Isotope Trends:  
French Creek at Dead Elk Pond

Figure A1-11c





## **Appendix 2**

### **Data Reports for Stable Isotope Analyses**



## Stable Isotope Analysis Results

Sample	$\delta D$	$\delta^{18}O$	Sample	$\delta D$	$\delta^{18}O$
FG001	-132	-17.7	FG0024	-142	-18.8
FG002	-131	-18.0	FG0025	-137	-17.8
FG003	-141	-18.9	FG0026	-145	-18.8
FG004	-136	-18.2	FG0027	-144	-18.8
FG005	-141	-18.8	FG0028	-139	-18.6
FG006	-141	-18.7	FG0029	-141	-18.7
FG007	-159	-21.0	FG0030	-146	-18.7
FG008	-133	-17.4	FG0031	-127	-17.8
FG009	-132	-18.0	FG0032	-139	-18.6
FG0010	-206	-27.2	FG0033	-127	-18.2
FG0011	-132	-18.1	FG0034	-127	-18.1
FG0012	-136	-18.0	FG0035	-135	-18.6
FG0013	-134	-18.1	FG0036	-122	-17.4
FG0014	-136	-18.1	FG0037	-131	-18.4
FG0015	-130	-17.8	FG0038	-135	-18.6
FG0016	-143	-18.4	FG0039	-135	-18.7
FG0017	-143	-18.5	FG0040	NA	-17.8
FG0018	-144	-18.6	FG0041	-142	-18.7
FG0019	-144	-18.6	FG0042	-126	-17.8
FG0020	-143	-18.5	FG0043	-136	-18.0
FG0021	-137	-18.1	FG0044	-127	-17.8
FG0022	-136	-18.0	FG0045	-125	-17.9
FG0023	-137	-18.0			

## Duplicate Analyses

Hydrogen Isotopes				Oxygen Isotopes			
Sample	Duplicate 1	Duplicate 2	SD	Sample	Duplicate 1	Duplicate 2	SD
FG0002	-17.9	-18.1	0.01	FG0001	-129	-135	3
FG0008	-17.4	-17.4	0.04	FG0002	-130	-132	1
FG0009	-18	-18	0.02	FG0022	-134	-138	2
FG0011	-18.1	-18.1	0.01	FG0024	-157	-157	0
Mean SD:			0.02	Mean SD:			1.6

Reviewed by:

  
 Leticia B. Menchaca

## ***Isotope Solutions***

*Isotopic Environmental Consultants*

*1126 Delaware St.*

*Berkeley CA 94702*

*Tel. (510) 527-7237*

*Fax (510) 528-9421*

*Email: menchaca@mindspring.com*

**IS-1007RAS3**

Project Name: French Gulch

Project No: STATE FG97

Contact: William Pedler/Art Morrissey

Company: RAS

Tel. (303) 517-0509 Fax. 279-2730

### **Analytical Report**

Well No.	Sample Number	Date	$\delta^{18}\text{O}$ (‰)	$\delta^{18}\text{O}$ Dup.	$\delta\text{D}$ (‰)	$\delta\text{D}$ Dup.
FG0010 rep	FG0048	6/24/97	-26.7		-207	-207
FG0005 rep	FG0049	6/24/97	-19.6		-143	-145
Standards			Measured	Accepted	Measured	Accepted
NH					35	34
NH-DUP					33	34
DL					-215	-214.7
DL-DUP					-215	-214.7
NI			-11.6	-11.6		
NI-DUP			-11.7	-11.6		

Reviewed by:

*L. B. Menchaca*  
Dr. Leticia B. Menchaca

Date: 2/28/97

# Isotope Solutions

## Isotope Solutions

Isotopic Environmental Consultants

1126 Delaware St.

Berkeley CA 94702

Tel. (510) 527-7237

Fax (510) 528-9421

IS-1007RAS3

Project Name: French Gulch

Project No: UDS197

Contact: William Pedler

Company: AGS

Tel. (303) 988-1845

## Analytical Report

Well No.	Sample Number	Date	$\delta^{18}\text{O}$ (‰)	$\delta^{18}\text{O}$ Dup.	$\delta\text{D}$ (‰)	$\delta\text{D}$ Dup.
FG0050	3806-1	1/21/97	-19.2		-146	-146
FG0051	3806-2	1/21/97	-19.4		-146	-147
FG0052	3806-3	1/21/97	-19.2		-146	-146
FG0053	3806-4	1/21/97	-19.0		-143	-143
FG0054	3806-5	1/21/97	-18.9	-18.8	-141	-142
Standards			Measured	Accepted	Measured	Accepted
NH					34	34
NH-DUP					35	34
DL					-214	-214.7
DL-DUP					-215	-214.7
NI			-11.7	-11.6		
NI-DUP			-11.6	-11.6		

Reviewed by:

  
Dr. Leticia B. Menchaca

Date: 2/4/97

## Isotope Solutions

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Berkeley CA 94702

Tel (510) 527-7237

Fax (510) 528-9421

Email: [menchaca@mindspring](mailto:menchaca@mindspring)

IS-1007RAS3

Project Name: French Gulch

Project No: STATE FG97

Contact: William Pedler/Art Morrissey


Company: RAS

Tel. (303) 517-0509 Fax. 279-2730

### Analytical Report

Well No.	Sample Number	Date	$\delta^{18}\text{O}$ (‰)	$\delta^{18}\text{O}$ Dup.	$\delta\text{D}$ (‰)	$\delta\text{D}$ Dup.
MW-14	FG0055	3/12/97	-18.2		-140	-143
MW-9	FG0056	3/12/97	-17.5		-132	-132
MSRW-3	FG0057	3/12/97	-18.5		-143	-143
MW-16	FG0058	3/12/97	-18.6		-137	-136
MW-2	FG0059	3/12/97	-18.2		-141	-139
MW-3	FG0060	3/12/97	-18.1		-138	-138
	FG0061	3/12/97	-18.2	-18.1	-141	-141
MW-11	FG0062	3/12/97	-17.6		-131	-131
MW-13	FG0063	3/12/97	-17.3		-136	-135
FG-6C	FG0064	3/13/97	-18.3		-146	-146
KDS	FG0065	3/13/97	-18.7		-149	-149
FC@CB	FG0066	3/13/97	-17.7		-135	-136
FG-7	FG0067	3/13/97	-17.8		-137	-137
FG-8	FG0068	3/13/97	-17.7	-17.6	-137	-137
MW-12	FG0069	3/13/97	-18.0		-140	-139
FG-1	FG0070	3/13/97	-17.6		-136	-133
MW-9 SNOW	FG0071	3/13/97	-23.6		-186	-187
FG-1 SNOW	FG0072	3/13/97	-22.4		-177	-176
FG-9	FG0073	3/13/97	-17.7		-138	-138
FG-15	FG0074	3/13/97	-17.8		-137	-136
1121	FG0075	3/13/97	-18.0		-140	-145
FG-6D	FG0076	3/13/97	-17.8		-139	-140
TS-4	FG0077	3/13/97	-17.8		-137	-137
SBRF3	FG0078	3/13/97	-17.3		-142	-140
Standards			Measured	Accepted	Measured	Accepted
NH					34	34
NH-DUP					34	34
DL					-214	-214.7
DL-DUP					-215	-214.7
NI			-11.7	-11.6		
NI-DUP			-11.6	-11.6		

Reviewed by:

  
Dr. Leticia B. Menchaca

Date: 4/17/97

# Isotope Solutions

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IS-1007RAS3

Project Name: French Gulch

Project No: STATE FG97

Contact: William Pedler/Art Morrissey


Company: RAS

Tel. (303) 517-0509 Fax. 279-2730

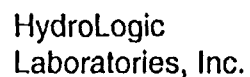
## Analytical Report

Well No.	Sample Number	Date	$\delta^{18}\text{O}$ (‰)	$\delta^{18}\text{O}$ Dup.	$\delta\text{D}$ (‰)	$\delta\text{D}$ Dup.
FG-9	FG0082	6/24/97	-17.8		-141	-141
FG-9 RAIN	FG0083	6/24/97	-17.0		-139	-140
FG-7	FG0084	6/24/97	-17.9		-141	-142
FG-8	FG0085	6/24/97	-17.9		-141	-140
1121	FG0086	6/24/97	-18.0		-140	-142
TS-04	FG0087	6/24/97	-18.0		-141	-140
FG-6D	FG0088	6/24/97	-17.8		-142	-142
FC-6C	FG0089	6/24/97	-18.3		-148	-150
FC@CB	FG0090	6/24/97	-18.4		-142	-142
FG-15	FG0091	6/24/97	-17.9	-18.0	-141	-141
FG-15rep	FG0092	6/24/97	-17.9		-139	-141
KDS	FG0093	6/24/97	-18.3		-148	-145
MW-9 SNOW	FG0094	6/24/97	-21.6		-174	-172
FG-1 SNOW	FG0095	6/24/97	-19.4		-155	-154
FG-1	FG0096	6/24/97	-18.3		-139	-140
MW-12	FG0097	6/24/97	-18.1		-149	-149
MW-14	FG0098	6/24/97	-18.3		-147	-148
MW-9	FG0099	6/24/97	-17.7		-139	-139
MW-11	FG0100	6/24/97	-18.0		-143	-142
Oro	FG0101	6/24/97	-17.7	-17.5	-139	-141
WRO-1	FG0102	6/24/97	-17.7		-145	-142
RF-3	FG0103	6/24/97	-17.2		-139	-140
MW-16	FG0104	6/24/97	-18.3		-148	-148
#3 Mine	FG0105	6/24/97	-18.5		-147	-147
Qal Seep	FG0106	6/24/97	-17.5		-145	-147
MW-13	FG0107	6/24/97	-17.3		-137	-140
WTL-02	FG0108	6/24/97	-17.5		-138	-138
MW-2	FG0109	6/24/97	-18.5		-145	-145
MW-3	FG0110	6/24/97	-18.3	-18.1	-145	-143
Standards			Measured	Accepted	Measured	Accepted
NH					36	34
NH-DUP					33	34
DL					-214	-214.7
DL-DUP					-215	-214.7
NI			-11.6	-11.6		
NI-DUP			-11.7	-11.6		

Reviewed by:

  
Dr. Leticia B. Menchaca

Date: 7/25/97



## CHAIN-OF-CUSTODY RECORD

ROSH TURNAOUND (10 days)

Page 1 of 1

Client Company RAS, INC. Phone # (303) 517-0509  
Client Contact Art Morrissey Fax # NA  
Project Location FRENCH GULCH Project Number JD0197

### Requested Parameters

ISOVOPK  
O<sub>2</sub> + V

[illegible]

Matrix Code:      W=Water              L=Liquid              S=Soil              O=Oil              SL=Sludge

		Date	Time
Relinquished by: (Signature) <i>Carl M. Morrissey</i>	Received by: (Signature) <i>L.B. [unclear]</i>	1/27/97	6pm-
Relinquished by: (Signature)	Received by: (Signature)		
Temp. ? Condition upon Receipt?	Received for Laboratory by:		

WHITE COPY - HYDROLOGIC LABORATORIES, INC.

**YELLOW COPY - CUSTOMER**



HydroLogic  
Laboratories, Inc.

# CHAIN-OF-CUSTODY RECORD

Page 1 of 2

695 N. 7th Ave.  
Brighton, Colorado 80601-1559 303-659-0497

Purchase Order # \_\_\_\_\_

Client Company RAS, INC. Phone # 303-517-0509

Client Contact Art Morrissey Fax # 303-279-2730

Project Location FRENCH GULCH Project Number State FG97

SAMPLE IDENTITY	Matrix Code	Date/Time Sampled	Type of Preservative	Requested Parameters								Total # of Containers
FG0055 (MW-4)	(W)	3/12/97 1245	None	ISOTOPIES O <sub>2</sub> + O								1
FG0056 (MW-9)		1330										
FG 0057 (MW-3)		1505										
FG0058 (MW-11)		1530										
FG0059 (MW-2)		1600										
FG0060 (MW-3)		1630										
FG0061		1630										
FG 0062 (MW-11)		1650										
FG0063 (MW-11)		1735										
FG0064 (FG-1)		3/13/97 1345										
FG0065 (KOS)		3/13/97 0915										
FG0066 (FCB)		3/13/97 1410										
FG0067 (FG-7)		3/13/97 1105										
FG0068 (FG-8)		3/13/97 1125										
FG0069 (MW-12)		3/13/97 1000										

Matrix Code: W=Water L=Liquid S=Soil O=Oil SL=Sludge

Relinquished by: (Signature) <u>Art Morrissey</u>	Received by: (Signature) <u>[Signature]</u>	Date	Time
Relinquished by: (Signature)	Received by: (Signature) <u>[Signature]</u>	3/14/97	11:30 AM
Temp.? Condition upon Receipt?	Received for Laboratory by:	3/27/97	4:30 pm

WHITE COPY - HYDROLOGIC LABORATORIES, INC.

YELLOW COPY - CUSTOMER



Purchase Order # \_\_\_\_\_

Page 2 of 2

Client Company RAS, INC Phone # 303-517-0509  
Client Contact Art Morrissey Fax # 303-279-2730  
Project Location FRENCH GULCH Project Number STATE FG97

### Requested Parameters

Isotopes  
 $O_2 + D$

[illegible]

Matrix Code:      W=Water              L=Liquid              S=Soil              O=Oil              SL=Sludge

Date \_\_\_\_\_ Time \_\_\_\_\_

Relinquished by: (Signature) <i>Cathy R. Morrissey</i>	Received by: (Signature) <i>W. H. [Signature]</i>		
Relinquished by: (Signature)	Received by: (Signature) <i>S. B. [Signature]</i>	3/27/97	4:30 pm
Temp. Condition upon Receipt?	Received for Laboratory by:		

WHITE COPY - HYDROLOGIC LABORATORIES, INC.

YES, I NOW COPY CUSTOMERS





HydroLogic  
Laboratories, Inc.

# CHAIN-OF-CUSTODY RECORD

Page 1 of 2

695 N. 7th Ave.  
Brighton, Colorado 80601-1559 303-659-0497

Purchase Order # \_\_\_\_\_

Client Company RAS, Inc. Phone # 988-1845

Client Contact Art Morrissey Fax # (303) 986-2898

Project Location FRENCH CULCH Project Number \_\_\_\_\_

SAMPLE IDENTITY	Matrix C. It.	Date/Time Sampled	Type of Preservative	Requested Parameters								Total # of Containers
				O <sub>2</sub> & D ISOTOPES	Sample Description							
FG0082	W	5/29/97 1015	None	X	FG-7 STREAM							1
FG0083		" 1020			FG-9 RAIN							
FG0084		" 1045			FG-7 STREAM							
FG0085		" 1115			FG-8 STREAM							
FG0086		" 1145			1121 SEEP							
FG0087		" 1200			USGS TS-4 - STREAM							
FG0088		" 1300			FG-6D SEEP							
FG0089		" 1315			FG-6C SEEP							
FG0090		" 1345			FG-6C STREAM							
FG0091		" 1400			USGS FG-15 STREAM FLOW							
FG0092		" 1400			"							
FG0093		" 1445			15 DS SPRING							
FG0094		" 1500			3-NDW @ MW-9							
FG0095		" 1515			3-NDW 1600 FG-1							
FG0096		" 1530			FG-1 STREAM							

Matrix Code: W=Water L=Liquid S=Soil O=Oil SL=Sludge

Relinquished by: (Signature)	Received by: (Signature) <u>TS Morrissey</u>	Date	Time
Relinquished by: (Signature)	Received by: (Signature)		
Temp? Condition upon Receipt?	Received for Laboratory by:		

WHITE COPY - HYDROLOGIC LABORATORIES, INC.

YELLOW COPY - CUSTOMER

# Chain of Custody Record



OUA-4124-1

Client <b>RAS, Inc.</b>		Project Manager <b>Art Morrissey</b>		Date <b>6/1/97</b>	Chain Of Custody Number <b>56990</b>
Address <b>311 Rock Ave</b>		Telephone Number (Area Code) Fax Number <b>(303) 988-1845 / 986-2898</b>		Lab Number	Page <b>2</b> of <b>2</b>
City <b>Golden</b>	State <b>CO</b>	Zip Code <b>80401</b>	Site Contact	Lab Contact	Analysis (Attach list if more space is needed)
Project Name <b>FRENCH GULCH</b>			Carrier/Vehicle Number		
Contract/Purchase Order/Quote No.			Matrix	Containers & Preservatives	Special Instructions, Conditions of Recel

Sample I.D. No. and Description (Containers for each sample may be combined on one line)	Date	Time	Aspirated	Sealed	Sealed	Sealed	Ungassed	HEXAM	HEXAM	HCl	NaOH	ZnAc	NaOH	Other
FG0097 (MW-12 GROUNDWATER)	5/30/97	940	X				X							
FG0098 (MW-14 GW)	"	1010												
FG0099 (MW-9 GW)	"	1035												
FG0100 (MW-11 GW)	"	1105												
FG0101 (ONO SHIFT)	"	1120												
FG0102 (WRO-1 GW)	"	1240												
FG0103 (SBRF-3 GW)	"	1310												
FG0104 (MW-16 GW)	"	1325												
FG0105 (#3 MW-16 SHIFT)	"	1345												
FG0106 (seep)	"	1415												
FG0107 (MW-13 GW)	"	1430												
FG0108 (WTL-02 GW)	"	1510												
FG0109 (MW-2 GW)	"	1520												
FG0110 (MW-3 GW)	"	1550												

Possible Hazard Identification		Sample Disposal		(A fee may be assessed if samples are retained longer than 3 months)	
<input checked="" type="checkbox"/> Non-Hazard	<input type="checkbox"/> Flammable	<input type="checkbox"/> Skin Irritant	<input type="checkbox"/> Poison B	<input type="checkbox"/> Unknown	<input type="checkbox"/> Return To Client
Turn Around Time Required		OC Requirements (Specify)			
<input type="checkbox"/> 24 Hours	<input type="checkbox"/> 48 Hours	<input type="checkbox"/> 7 Days	<input type="checkbox"/> 14 Days	<input type="checkbox"/> 21 Days	<input type="checkbox"/> Other <b>Normal</b>
1. Relinquished By	Date	Time	1. Received By	Date	Time
			<b>AS Francisco L.</b>	<b>6-24-97</b>	<b>4pm</b>
2. Relinquished By	Date	Time	2. Received By	Date	Time
3. Relinquished By	Date	Time	3. Received By	Date	Time
Comments					

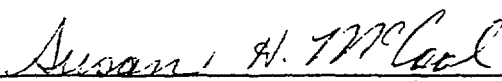
DISTRIBUTION: WHITE - Stays with the Sample; CANARY - Returned to Client with Report; PINK - Field Copy

## **Appendix 3**

### **Data Reports for Metals Analyses**

ANALYTICAL RESULTS  
FOR  
R.A.S., Inc.  
FRENCH GULCH WATERSHEAD STUDY  
QUANTERRA ENVIRONMENTAL SERVICES  
DENVER NO. 047974  
APRIL 4, 1996

Reviewed by:

  
\_\_\_\_\_  
Susan H. McCool

## Introduction

This report presents the analytical results as well as supporting information to aid in the evaluation and interpretation of the data and is arranged in the following order:

- o Sample Description Information
- o Analytical Test Requests
- o Analytical Results

All analyses at Quanterra are performed so that the maximum concentration of sample consistent with the method is analyzed. Dilutions are at times required to avoid saturation of the detector, to achieve linearity for a specific target compound, or to reduce matrix interferences. In this event, reporting limits are adjusted proportionately.

Samples 047974-0004 through -0006 were analyzed at dilutions for method 6010 due to the elevated concentration of zinc in the samples. The reporting limits were raised relative to the dilutions required.

Sample 047974-0008 was analyzed at a dilution for method 6010 due to the elevated concentrations of zinc and iron in the sample. The reporting limits were raised relative to the dilution required.

## Sample Description Information

The Sample Description Information lists all of the samples received in this project together with the internal laboratory identification number assigned for each sample. Each project received at Quanterra's Denver laboratory is assigned a unique six digit number. Samples within the project are numbered sequentially. The laboratory identification number is a combination of the six digit project code and the sample sequence number.

Also given in the Sample Description Information is the Sample Type (matrix), Date of Sampling (if known) and Date of Receipt at the laboratory.

## Analytical Test Requests

The Analytical Test Requests lists the analyses that were performed on each sample. The Custom Test column indicates where tests have been modified to conform to the specific requirements of this project.

SAMPLE DESCRIPTION INFORMATION  
for  
R.A.S. Inc.

Lab ID	Client ID	Matrix	Sampled Date      Time	Received Date
047974-0001-SA	FG0001	AQUEOUS	20 MAR 96	21 MAR 96
047974-0002-SA	FG0002	AQUEOUS	20 MAR 96	21 MAR 96
047974-0003-SA	FG0003	AQUEOUS	20 MAR 96	21 MAR 96
047974-0004-SA	FG0004	AQUEOUS	20 MAR 96	21 MAR 96
047974-0005-SA	FG0005	AQUEOUS	20 MAR 96	21 MAR 96
047974-0006-SA	FG0006	AQUEOUS	20 MAR 96	21 MAR 96
047974-0007-SA	FG0007	AQUEOUS	20 MAR 96	21 MAR 96
047974-0008-SA	FG0008	AQUEOUS	20 MAR 96	21 MAR 96
047974-0009-SA	FG0009	AQUEOUS	20 MAR 96	21 MAR 96
047974-0010-SA	FG0011	AQUEOUS	20 MAR 96	21 MAR 96

ANALYTICAL TEST REQUESTS  
for  
Colorado Division of Minerals & Geology

Lab ID: 047974	Group Code	Analysis Description	Custom Test?
0001 - 0010	A	ICP Metals (Total) Prep - Total Metals, ICP	Y N

## **Analytical Results**

The analytical results for this project are presented in the following data tables. Each data table includes sample identification information, and when available and appropriate, dates sampled, received, authorized, prepared and analyzed. The authorization data is the date when the project was defined by the client such that laboratory work could begin.

Data sheets contain a listing of the parameters measured in each test, the analytical results and the Quanterra reporting limit. Reporting limits are adjusted to reflect dilution of the sample, when appropriate.

The results from the Standard Quanterra QA/QC Program, which generates data which are independent of matrix effects, are provided subsequently.





## Metals

## Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0001  
Lab ID: 047974-0001-SA  
Matrix: AQUEOUS  
Authorized: 22 MAR 96

Sampled: 20 MAR 96  
Prepared: See Below

Received: 21 MAR 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.013	mg/L	0.0050	6010	26 MAR 96	01 APR 96
Iron	1.7	mg/L	0.10	6010	26 MAR 96	01 APR 96
Zinc	0.39	mg/L	0.020	6010	26 MAR 96	01 APR 96

ND = Not detected  
NA = Not applicable

Reported By: Kaye Ryman

Approved By: Kristina Sanchez

**Metals****Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0002  
Lab ID: 047974-0002-SA  
Matrix: AQUEOUS  
Authorized: 22 MAR 96

Sampled: 20 MAR 96  
Prepared: See Below

Received: 21 MAR 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	ND	mg/L	0.0050	6010	26 MAR 96	01 APR 96
Iron	0.51	mg/L	0.10	6010	26 MAR 96	01 APR 96
Zinc	0.092	mg/L	0.020	6010	26 MAR 96	01 APR 96

ND = Not detected  
NA = Not applicable

Reported By: Kaye Ryman

Approved By: Kristina Sanchez



Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0003  
Lab ID: 047974-0003-SA  
Matrix: AQUEOUS  
Authorized: 22 MAR 96

Sampled: 20 MAR 96  
Prepared: See Below  
Received: 21 MAR 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.046	mg/L	0.0050	6010	26 MAR 96	01 APR 96
Iron	99.3	mg/L	0.10	6010	26 MAR 96	01 APR 96
Zinc	96.8	mg/L	0.020	6010	26 MAR 96	01 APR 96

ND = Not detected  
NA = Not applicable

Reported By: Kaye Ryman

Approved By: Kristina Sanchez

**Metals****Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0004  
Lab ID: 047974-0004-SA  
Matrix: AQUEOUS  
Authorized: 22 MAR 96

Sampled: 20 MAR 96  
Prepared: See Below

Received: 21 MAR 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.12	mg/L	0.010	6010	26 MAR 96	03 APR 96
Iron	211	mg/L	0.20	6010	26 MAR 96	03 APR 96
Zinc	167	mg/L	0.040	6010	26 MAR 96	03 APR 96

ND = Not detected  
NA = Not applicable

Reported By: Kaye Ryman

Approved By: Kristina Sanchez

## Metals

## Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0005  
Lab ID: 047974-0005-SA  
Matrix: AQUEOUS  
Authorized: 22 MAR 96

Sampled: 20 MAR 96  
Prepared: See Below

Received: 21 MAR 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.20	mg/L	0.010	6010	26 MAR 96	03 APR 96
Iron	188	mg/L	0.20	6010	26 MAR 96	03 APR 96
Zinc	165	mg/L	0.040	6010	26 MAR 96	03 APR 96

ND = Not detected  
NA = Not applicable

Reported By: Kaye Ryman

Approved By: Kristina Sanchez

Metals

Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0006  
Lab ID: 047974-0006-SA  
Matrix: AQUEOUS  
Authorized: 22 MAR 96

Sampled: 20 MAR 96  
Prepared: See Below

Received: 21 MAR 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.14	mg/L	0.010	6010	26 MAR 96	03 APR 96
Iron	201	mg/L	0.20	6010	26 MAR 96	03 APR 96
Zinc	159	mg/L	0.040	6010	26 MAR 96	03 APR 96

ND = Not detected  
NA = Not applicable

Reported By: Kaye Ryman

Approved By: Kristina Sanchez



## Metals

## Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0007  
Lab ID: 047974-0007-SA  
Matrix: AQUEOUS  
Authorized: 22 MAR 96

Sampled: 20 MAR 96  
Prepared: See Below

Received: 21 MAR 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.072	mg/L	0.0050	6010	26 MAR 96	01 APR 96
Iron	16.7	mg/L	0.10	6010	26 MAR 96	01 APR 96
Zinc	18.4	mg/L	0.020	6010	26 MAR 96	01 APR 96

ND = Not detected  
NA = Not applicable

Reported By: Kaye Ryman

Approved By: Kristina Sanchez

**Metals****Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0008  
Lab ID: 047974-0008-SA  
Matrix: AQUEOUS  
Authorized: 22 MAR 96

Sampled: 20 MAR 96  
Prepared: See Below

Received: 21 MAR 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	ND	mg/L	0.50	6010	26 MAR 96	03 APR 96
Iron	26900	mg/L	10.0	6010	26 MAR 96	03 APR 96
Zinc	4530	mg/L	2.0	6010	26 MAR 96	03 APR 96

ND = Not detected  
NA = Not applicable

Reported By: Kaye Ryman

Approved By: Kristina Sanchez





## Metals

## Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0009  
Lab ID: 047974-0009-SA  
Matrix: AQUEOUS  
Authorized: 22 MAR 96

Sampled: 20 MAR 96  
Prepared: See Below

Received: 21 MAR 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	ND	mg/L	0.0050	6010	26 MAR 96	01 APR 96
Iron	2.2	mg/L	0.10	6010	26 MAR 96	01 APR 96
Zinc	0.40	mg/L	0.020	6010	26 MAR 96	01 APR 96

ND = Not detected  
NA = Not applicable

Reported By: Kaye Ryman

Approved By: Kristina Sanchez

## Metals

## Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0011  
Lab ID: 047974-0010-SA  
Matrix: AQUEOUS  
Authorized: 22 MAR 96

Sampled: 20 MAR 96  
Prepared: See Below

Received: 21 MAR 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.027	mg/L	0.0050	6010	26 MAR 96	01 APR 96
Iron	1.3	mg/L	0.10	6010	26 MAR 96	01 APR 96
Zinc	13.4	mg/L	0.020	6010	26 MAR 96	01 APR 96

ND = Not detected  
NA = Not applicable

Reported By: Kaye Ryman

Approved By: Kristina Sanchez



QC LOT ASSIGNMENT REPORT  
Metals Analysis and Preparation

Laboratory Sample Number	QC Matrix	QC Category	QC Lot Number (DCS)	QC Run Number (SCS/BLANK)
047974-0001-SA	AQUEOUS	ICP-AT	26 MAR 96-SF	26 MAR 96-SF
047974-0002-SA	AQUEOUS	ICP-AT	26 MAR 96-SF	26 MAR 96-SF
047974-0003-SA	AQUEOUS	ICP-AT	26 MAR 96-SF	26 MAR 96-SF
047974-0004-SA	AQUEOUS	ICP-AT	26 MAR 96-SF	26 MAR 96-SF
047974-0005-SA	AQUEOUS	ICP-AT	26 MAR 96-SF	26 MAR 96-SF
047974-0006-SA	AQUEOUS	ICP-AT	26 MAR 96-SF	26 MAR 96-SF
047974-0007-SA	AQUEOUS	ICP-AT	26 MAR 96-SF	26 MAR 96-SF
047974-0008-SA	AQUEOUS	ICP-AT	26 MAR 96-SF	26 MAR 96-SF
047974-0009-SA	AQUEOUS	ICP-AT	26 MAR 96-SF	26 MAR 96-SF
047974-0010-SA	AQUEOUS	ICP-AT	26 MAR 96-SF	26 MAR 96-SF

LABORATORY CONTROL SAMPLE REPORT  
Metals Analysis and Preparation

Analyte	Concentration		Accuracy(%)	
	Spiked	Measured	LCS	Limits
Category: ICP-AT				
Matrix: AQUEOUS				
QC Lot: 26 MAR 96-SF      QC Run: 26 MAR 96-SF				
Concentration Units: mg/L				
Aluminum	2.00	2.10	105	80-116
Antimony	0.500	0.469	94	80-115
Arsenic	0.500	0.498	100	80-115
Barium	2.00	2.07	103	80-114
Beryllium	0.0500	0.0517	103	80-120
Boron	10.0	9.74	97	80-120
Cadmium	0.0500	0.0456	91	80-119
Calcium	100	100	100	80-114
Chromium	0.200	0.209	104	80-116
Cobalt	0.500	0.510	102	80-114
Copper	0.250	0.256	102	80-120
Iron	1.00	1.05	105	80-120
Lead	0.500	0.530	106	80-119
Lithium	10.0	10.5	105	80-120
Magnesium	50.0	51.4	103	81-120
Manganese	0.500	0.509	102	80-116
Molybdenum	0.500	0.501	100	80-120
Nickel	0.500	0.502	100	80-114
Potassium	50.0	52.3	105	80-120
Selenium	0.500	0.529	106	80-120
Silver	0.0500	0.0488	98	80-119
Sodium	100	102	102	80-120
Tin	0.500	0.485	97	80-120
Titanium	0.500	0.504	101	80-120
Vanadium	0.500	0.515	103	80-116
Zinc	0.500	0.516	103	80-120

Calculations are performed before rounding to avoid round-off errors in calculated results.



METHOD BLANK REPORT  
Metals Analysis and Preparation

Analyte	Result	Units	Reporting Limit
Test: ICP-AT			
Matrix: AQUEOUS			
QC Lot: 26 MAR 96-SF QC Run: 26 MAR 96-SF			
Cadmium	ND	mg/L	0.0050
Iron	ND	mg/L	0.10
Zinc	ND	mg/L	0.020

QC LOT ASSIGNMENT REPORT - MS QC  
Metals Analysis and Preparation

Laboratory Sample Number	QC Matrix	QC Category	QC Lot Number (DCS)	QC Run Number (SCS/BLANK)	MS QC Run Number (SA,MS,SD,DU)
047974-0001-SA	AQUEOUS	ICP-AT	26 MAR 96-SF	26 MAR 96-SF	26 MAR 96-SF
047974-0002-SA	AQUEOUS	ICP-AT	26 MAR 96-SF	26 MAR 96-SF	26 MAR 96-SF
047974-0003-SA	AQUEOUS	ICP-AT	26 MAR 96-SF	26 MAR 96-SF	26 MAR 96-SF
047974-0004-SA	AQUEOUS	ICP-AT	26 MAR 96-SF	26 MAR 96-SF	26 MAR 96-SF
047974-0005-SA	AQUEOUS	ICP-AT	26 MAR 96-SF	26 MAR 96-SF	26 MAR 96-SF
047974-0006-SA	AQUEOUS	ICP-AT	26 MAR 96-SF	26 MAR 96-SF	26 MAR 96-SF
047974-0007-SA	AQUEOUS	ICP-AT	26 MAR 96-SF	26 MAR 96-SF	26 MAR 96-SF
047974-0008-SA	AQUEOUS	ICP-AT	26 MAR 96-SF	26 MAR 96-SF	26 MAR 96-SF
047974-0009-SA	AQUEOUS	ICP-AT	26 MAR 96-SF	26 MAR 96-SF	26 MAR 96-SF
047974-0010-SA	AQUEOUS	ICP-AT	26 MAR 96-SF	26 MAR 96-SF	26 MAR 96-SF



MATRIX SPIKE/MATRIX SPIKE DUPLICATE QC REPORT  
Metals Analysis and Preparation  
Project: 047974

Category: ICP-AT ICP Metals / Total  
Matrix: AQUEOUS  
Sample: 047974-0001  
QC Lot: 26 MAR 96-SF MS Run: 26 MAR 96-SF  
Units: mg/L Units Qualifier:

Analyte	Concentration			Amount MS	Spiked MSD	%Recovery		%RPD MS-MSD
	Sample Result	MS Result	MSD Result			MS	MSD	
Aluminum	NA	NA	NA	2.0	2.0	NC	NC	NC
Antimony	NA	NA	NA	0.50	0.50	NC	NC	NC
Arsenic	NA	NA	NA	0.50	0.50	NC	NC	NC
Barium	NA	NA	NA	2.0	2.0	NC	NC	NC
Beryllium	NA	NA	NA	0.050	0.050	NC	NC	NC
Boron	NA	NA	NA	10	10	NC	NC	NC
Cadmium	0.013	0.062	0.061	0.050	0.050	98	95	2.6
Calcium	NA	NA	NA	100	100	NC	NC	NC
Chromium	NA	NA	NA	0.20	0.20	NC	NC	NC
Cobalt	NA	NA	NA	0.50	0.50	NC	NC	NC
Copper	NA	NA	NA	0.25	0.25	NC	NC	NC
Iron	1.7	2.8	2.8	1.0	1.0	103	102	0.94
Lead	NA	NA	NA	0.50	0.50	NC	NC	NC
Lithium	NA	NA	NA	5.0	5.0	NC	NC	NC
Magnesium	NA	NA	NA	50	50	NC	NC	NC
Manganese	NA	NA	NA	0.50	0.50	NC	NC	NC
Molybdenum	NA	NA	NA	0.50	0.50	NC	NC	NC
Nickel	NA	NA	NA	0.50	0.50	NC	NC	NC
Potassium	NA	NA	NA	50	50	NC	NC	NC
Selenium	NA	NA	NA	0.50	0.50	NC	NC	NC
Silver	NA	NA	NA	0.050	0.050	NC	NC	NC
Sodium	NA	NA	NA	100	100	NC	NC	NC
Thallium	NA	NA	NA	5.0	5.0	NC	NC	NC
Tin	NA	NA	NA	0.50	0.50	NC	NC	NC
Titanium	NA	NA	NA	0.50	0.50	NC	NC	NC
Vanadium	NA	NA	NA	0.50	0.50	NC	NC	NC
Zinc	0.39	0.91	0.91	0.50	0.50	104	105	0.56

= Not Applicable

= Not Calculated, calculation not applicable.

Calculations are performed before rounding to avoid round-off errors in calculated results.



Quanterra Incorporated  
4955 Yarrow Street  
Arvada, Colorado 80002

303 421-6611 Telephone  
303 431-7171 Fax

June 24, 1996

Mr. Bill Pedler  
R.A.S., Inc.  
311 Rock Avenue  
Golden, CO 80401

Dear Mr. Pedler:

Enclosed is the report for eleven samples received at Quanterra Environmental Services, Denver laboratory on June 11, 1996.

Included with the report is a quality control summary.

Please call if you have any questions.

Sincerely,

A handwritten signature in cursive script that reads "Susan H. McCool".

Susan H. McCool  
Project Administrator

Enclosures

Quanterra #049512



# Invoice



Environmental  
Services

Quanterra Environmental Services  
4955 Yarrow Street  
Arvada, CO 80002  
Tel: (303)421-6611  
Fax: (303)431-7171

REMIT  
TO:

Quanterra, Incorporated  
P.O. Box 91501  
Chicago, IL 606931501

Bill To:

Bill Pedler  
R.A.S. Inc.  
311 Rock Avenue  
Golden, CO 80401

Number

0028114831

Quanterra Project Number

RMAL-049512

Terms

NET 30 DAYS

Customer Contact

Date

24 JUN 96

Customer Number

00374328

Bill Pedler  
R.A.S. Inc.  
311 Rock Avenue  
Golden, CO 80401

Line No.	Qty.	Matrix Code	Analysis Description	Unit Price	Extended P
1	11	AQUEOUS	ANALYTICAL SERVICES Method 6010 - ICP Metals (Total)	59.00	649.0
			Analytical Services Subtotal	649.00	
			ADDITIONAL SERVICES		
			Additional Services Subtotal	0.00	

Customer P.O. Number Contract Number Reference

verbal per Bill Pedler

Quanterra Program Administrator

Susan McCool

Salesperson

Lisa Davis

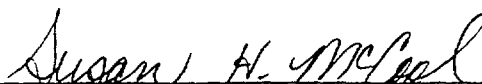
Sub Total 649.  
Tax  
Total 649

QUA-4027-B

Federal Tax I.C. :

ANALYTICAL RESULTS  
FOR  
R.A.S., Inc.  
FRENCH GULCH WATERSHEAD STUDY  
QUANTERRA ENVIRONMENTAL SERVICES  
DENVER NO. 049512  
JUNE 24, 1996

Reviewed by:

  
Susan H. McCool

## Introduction

This report presents the analytical results as well as supporting information to aid in the evaluation and interpretation of the data and is arranged in the following order:

- o Sample Description Information
- o Analytical Test Requests
- o Analytical Results

All analyses at Quanterra are performed so that the maximum concentration of sample consistent with the method is analyzed. Dilutions are at times required to avoid saturation of the detector, to achieve linearity for a specific target compound, or to reduce matrix interferences. In this event, reporting limits are adjusted proportionately.

All of the zinc reporting limits were raised for all of the samples due to a low level result detected in the instrument blank at the end of the analysis sequence. The blank solutions were remade and the zinc was not detected indicating possible low level contamination. In addition, samples 049512-0004 through -0007, and -0009 were analyzed at dilutions for method 6010 due to the elevated concentration of zinc in the samples. The reporting limits were raised relative to the dilutions required.

## Sample Description Information

The Sample Description Information lists all of the samples received in this project together with the internal laboratory identification number assigned for each sample. Each project received at Quanterra's Denver laboratory is assigned a unique six digit number. Samples within the project are numbered sequentially. The laboratory identification number is a combination of the six digit project code and the sample sequence number.

Also given in the Sample Description Information is the Sample Type (matrix), Date of Sampling (if known) and Date of Receipt at the laboratory.

## Analytical Test Requests

The Analytical Test Requests lists the analyses that were performed on each sample. The Custom Test column indicates where tests have been modified to conform to the specific requirements of this project.

## LIMs Report Key

Section	Description
Cover Letter	Signature page, report narrative as applicable.
Sample Description Information	Tabulated cross-reference between the Lab ID and Client ID, including matrix, date and time sampled, and the date received for all samples in the project.
Sample Analysis Results Sheets	Lists sample results, test components, reporting limits, dates prepared and analyzed, and any data qualifiers. Pages are organized by test.
QC LOT Assignment Report	Cross-reference between lab IDs and applicable QC batches (DCS, LCS, Blank, MS/SD, DU)
Duplicate Control Sample Report	Percent recovery and RPD results, with acceptance limits, for the laboratory duplicate control samples for each test are tabulated in this report. These are measures of accuracy and precision for each test. Acceptance limits are based upon laboratory historical data.
Laboratory Control Sample Report	Percent recovery results for a single Laboratory Control Sample (if applicable) are tabulated in this report, with the applicable acceptance limits for each test.
Matrix Spike/Matrix Spike Duplicate Report	Percent recovery and RPD results for matrix-specific QC samples and acceptance limits, where applicable. This report can be used to assess matrix effects on an analysis.
Single Control Sample Report	A tabulation of the surrogate recoveries for the blank for organic analyses.
Method Blank Report	A summary of the results of the analysis of the method blank for each test.

## List of Abbreviations and Terms

Abbreviation	Term	Abbreviation	Term
DCS	Duplicate Control Sample	MSD	Matrix Spike Duplicate
DU	Sample Duplicate	QC Run	Preparation Batch
EB	Equipment Blank	QC Category	LIMs QC Category
FB	Field Blank	QC Lot	DCS Batch
FD	Field Duplicate	ND	Not Detected at or above the reporting limit expressed
IDL	Instrument Detection Limit (Metals)	QC Matrix	Matrix of the laboratory control sample(s)
LCS	Laboratory Control Sample	RL	Reporting Limit
MB	Method Blank	QC	Quality Control
MDL	Method Detection Limit	SA	Sample
MS	Matrix Spike	SD	Spike Duplicate
RPD	Relative Percent Difference	TB	Trip Blank
ppm (part-per-million)	mg/L or mg/kg (usually)	ppb (part-per-billion)	ug/L or ug/kg (usually)
QUAL	Qualifier flag	DIL	Dilution Factor

SAMPLE DESCRIPTION INFORMATION  
for  
R.A.S. Inc.

Lab ID	Client ID	Matrix	Sampled Date	Time	Received Date
049512-0001-SA	FG0012	AQUEOUS	10 JUN 96		11 JUN 96
049512-0002-SA	FG0013	AQUEOUS	10 JUN 96		11 JUN 96
049512-0003-SA	FG0014	AQUEOUS	10 JUN 96		11 JUN 96
049512-0004-SA	FG0015	AQUEOUS	10 JUN 96		11 JUN 96
049512-0005-SA	FG0016	AQUEOUS	10 JUN 96		11 JUN 96
049512-0006-SA	FG0017	AQUEOUS	10 JUN 96		11 JUN 96
049512-0007-SA	FG0018	AQUEOUS	10 JUN 96		11 JUN 96
049512-0008-SA	FG0019	AQUEOUS	10 JUN 96		11 JUN 96
049512-0009-SA	FG0020	AQUEOUS	10 JUN 96		11 JUN 96
049512-0010-SA	FG0021	AQUEOUS	10 JUN 96		11 JUN 96
049512-0011-SA	FG0022	AQUEOUS	10 JUN 96		11 JUN 96

ANALYTICAL TEST REQUESTS  
for  
R.A.S. Inc.

Lab ID: 049512	Group Code	Analysis Description	Custom Test?
0001 - 0011	A	ICP Metals (Total) Prep - Total Metals, ICP	Y N

## Analytical Results

The analytical results for this project are presented in the following data tables. Each data table includes sample identification information, and when available and appropriate, dates sampled, received, authorized, prepared and analyzed. The authorization data is the date when the project was defined by the client such that laboratory work could begin.

Data sheets contain a listing of the parameters measured in each test, the analytical results and the Quanterra reporting limit. Reporting limits are adjusted to reflect dilution of the sample, when appropriate.

The results from the Standard Quanterra QA/QC Program, which generates data which are independent of matrix effects, are provided subsequently.

**Metals****Total Metals**

Client Name: R.A.S. Inc.

Client ID: FG0012

Lab ID: 049512-0001-SA

Matrix: AQUEOUS

Authorized: 11 JUN 96

Sampled: 10 JUN 96

Prepared: See Below

Received: 11 JUN 96

Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.0054	mg/L	0.0050	6010	12 JUN 96	19 JUN 96
Iron	0.46	mg/L	0.10	6010	12 JUN 96	19 JUN 96
Zinc	0.13	mg/L	0.051	6010	12 JUN 96	19 JUN 96

ND = Not detected  
NA = Not applicable

Reported By: Patrick Carroll

Approved By: Kristina Sanchez



**Metals****Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0013  
Lab ID: 049512-0002-SA  
Matrix: AQUEOUS  
Authorized: 11 JUN 96

Sampled: 10 JUN 96  
Prepared: See Below

Received: 11 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.010	mg/L	0.0050	6010	12 JUN 96	19 JUN 96
Iron	5.9	mg/L	0.10	6010	12 JUN 96	19 JUN 96
Zinc	1.7	mg/L	0.051	6010	12 JUN 96	19 JUN 96

ND = Not detected  
NA = Not applicable

Reported By: Patrick Carroll

Approved By: Kristina Sanchez

**Metals****Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0014  
Lab ID: 049512-0003-SA  
Matrix: AQUEOUS  
Authorized: 11 JUN 96

Sampled: 10 JUN 96  
Prepared: See Below

Received: 11 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	ND	mg/L	0.0050	6010	12 JUN 96	19 JUN 96
Iron	ND	mg/L	0.10	6010	12 JUN 96	19 JUN 96
Zinc	ND	mg/L	0.051	6010	12 JUN 96	19 JUN 96

ND = Not detected  
NA = Not applicable

Reported By: Patrick Carroll

Approved By: Kristina Sanchez

**Metals****Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0015  
Lab ID: 049512-0004-SA  
Matrix: AQUEOUS  
Authorized: 11 JUN 96

Sampled: 10 JUN 96  
Prepared: See Below

Received: 11 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	13.0	mg/L	0.25	6010	12 JUN 96	19 JUN 96
Iron	4090	mg/L	5.0	6010	12 JUN 96	19 JUN 96
Zinc	3160	mg/L	2.6	6010	12 JUN 96	19 JUN 96

ND = Not detected  
NA = Not applicable

Reported By: Patrick Carroll

Approved By: Kristina Sanchez

# Metals

## Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0016  
Lab ID: 049512-0005-SA  
Matrix: AQUEOUS  
Authorized: 11 JUN 96

Sampled: 10 JUN 96  
Prepared: See Below

Received: 11 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.34	mg/L	0.025	6010	12 JUN 96	19 JUN 96
Iron	297	mg/L	0.50	6010	12 JUN 96	19 JUN 96
Zinc	277	mg/L	0.26	6010	12 JUN 96	19 JUN 96

ND = Not detected  
NA = Not applicable

Reported By: Patrick Carroll

Approved By: Kristina Sanchez

# Metals

## Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0017  
Lab ID: 049512-0006-SA  
Matrix: AQUEOUS  
Authorized: 11 JUN 96

Sampled: 10 JUN 96  
Prepared: See Below

Received: 11 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.63	mg/L	0.025	6010	12 JUN 96	19 JUN 96
Iron	169	mg/L	0.50	6010	12 JUN 96	19 JUN 96
Zinc	230	mg/L	0.26	6010	12 JUN 96	19 JUN 96

ND = Not detected  
NA = Not applicable

Reported By: Patrick Carroll

Approved By: Kristina Sanchez

**Metals**

**Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0018  
Lab ID: 049512-0007-SA  
Matrix: AQUEOUS  
Authorized: 11 JUN 96

Sampled: 10 JUN 96  
Prepared: See Below

Received: 11 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.072	mg/L	0.010	6010	12 JUN 96	19 JUN 96
Iron	120	mg/L	0.20	6010	12 JUN 96	19 JUN 96
Zinc	127	mg/L	0.10	6010	12 JUN 96	19 JUN 96

ND = Not detected  
NA = Not applicable

Reported By: Patrick Carroll

Approved By: Kristina Sanchez

**Metals****Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0019  
Lab ID: 049512-0008-SA  
Matrix: AQUEOUS  
Authorized: 11 JUN 96

Sampled: 10 JUN 96  
Prepared: See Below

Received: 11 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.017	mg/L	0.0050	6010	12 JUN 96	19 JUN 96
Iron	2.1	mg/L	0.10	6010	12 JUN 96	19 JUN 96
Zinc	9.6	mg/L	0.051	6010	12 JUN 96	19 JUN 96

ND = Not detected  
NA = Not applicable

Reported By: Patrick Carroll

Approved By: Kristina Sanchez

**Metals****Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0020  
Lab ID: 049512-0009-SA  
Matrix: AQUEOUS  
Authorized: 11 JUN 96

Sampled: 10 JUN 96  
Prepared: See Below

Received: 11 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.54	mg/L	0.25	6010	12 JUN 96	19 JUN 96
Iron	165	mg/L	5.0	6010	12 JUN 96	19 JUN 96
Zinc	355	mg/L	2.6	6010	12 JUN 96	19 JUN 96

ND = Not detected  
NA = Not applicable

Reported By: Patrick Carroll

Approved By: Kristina Sanchez



Metals

Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0021  
Lab ID: 049512-0010-SA  
Matrix: AQUEOUS  
Authorized: 11 JUN 96

Sampled: 10 JUN 96  
Prepared: See Below

Received: 11 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.0089	mg/L	0.0050	6010	12 JUN 96	19 JUN 96
Iron	0.64	mg/L	0.10	6010	12 JUN 96	19 JUN 96
Zinc	2.6	mg/L	0.051	6010	12 JUN 96	19 JUN 96

ND = Not detected  
NA = Not applicable

Reported By: Patrick Carroll

Approved By: Kristina Sanchez

**Metals****Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0022  
Lab ID: 049512-0011-SA  
Matrix: AQUEOUS  
Authorized: 11 JUN 96

Sampled: 10 JUN 96  
Prepared: See Below

Received: 11 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.0064	mg/L	0.0050	6010	12 JUN 96	19 JUN 96
Iron	0.16	mg/L	0.10	6010	12 JUN 96	19 JUN 96
Zinc	0.76	mg/L	0.051	6010	12 JUN 96	19 JUN 96

ND = Not detected  
NA = Not applicable

Reported By: Patrick Carroll

Approved By: Kristina Sanchez

QC LOT ASSIGNMENT REPORT  
Metals Analysis and Preparation

Laboratory Sample Number	QC Matrix	QC Category	QC Lot Number (DCS)	QC Run Number (SCS/BLANK)
049512-0001-SA	AQUEOUS	ICP-AT	12 JUN 96-N1	12 JUN 96-N1
049512-0002-SA	AQUEOUS	ICP-AT	12 JUN 96-N1	12 JUN 96-N1
049512-0003-SA	AQUEOUS	ICP-AT	12 JUN 96-N1	12 JUN 96-N1
049512-0004-SA	AQUEOUS	ICP-AT	12 JUN 96-N1	12 JUN 96-N1
049512-0005-SA	AQUEOUS	ICP-AT	12 JUN 96-N1	12 JUN 96-N1
049512-0006-SA	AQUEOUS	ICP-AT	12 JUN 96-N1	12 JUN 96-N1
049512-0007-SA	AQUEOUS	ICP-AT	12 JUN 96-N1	12 JUN 96-N1
049512-0008-SA	AQUEOUS	ICP-AT	12 JUN 96-N1	12 JUN 96-N1
049512-0009-SA	AQUEOUS	ICP-AT	12 JUN 96-N1	12 JUN 96-N1
049512-0010-SA	AQUEOUS	ICP-AT	12 JUN 96-N1	12 JUN 96-N1
049512-0011-SA	AQUEOUS	ICP-AT	12 JUN 96-N1	12 JUN 96-N1

LABORATORY CONTROL SAMPLE REPORT  
Metals Analysis and Preparation

Analyte	Concentration		Accuracy(%)	
	Spiked	Measured	LCS	Limits
Category: ICP-AT				
Matrix: AQUEOUS				
QC Lot: 12 JUN 96-N1      QC Run: 12 JUN 96-N1				
Concentration Units: mg/L				
Aluminum	2.00	2.16	108	80-116
Antimony	0.500	0.466	93	80-115
Arsenic	2.00	1.88	94	80-115
Barium	2.00	1.96	98	80-114
Beryllium	0.0500	0.0480	96	80-120
Boron	1.00	1.07	107	80-120
Cadmium	0.0500	0.0441	88	80-119
Calcium	50.0	48.3	97	80-114
Chromium	0.200	0.182	91	80-116
Cobalt	0.500	0.488	98	80-114
Copper	0.250	0.248	99	80-120
Iron	1.00	1.09	109	80-120
Lead	0.500	0.485	97	80-119
Lithium	1.00	0.961	96	80-120
Magnesium	50.0	48.6	97	81-120
Manganese	0.500	0.488	98	80-116
Molybdenum	1.00	0.955	95	80-120
Nickel	0.500	0.475	95	80-114
Potassium	50.0	47.9	96	80-120
Selenium	2.00	2.05	102	80-120
Silver	0.0500	0.0490	98	80-119
Sodium	50.0	49.5	99	80-120
Tin	2.00	1.93	97	80-120
Titanium	1.00	0.998	100	80-120
Vanadium	0.500	0.486	97	80-116
Zinc	0.500	0.462	92	80-120

Calculations are performed before rounding to avoid round-off errors in calculated result

METHOD BLANK REPORT  
Metals Analysis and Preparation

Analyte	Result	Units	Reporting Limit
Test: ICP-AT			
Matrix: AQUEOUS			
QC Lot: 12 JUN 96-N1 QC Run: 12 JUN 96-N1			
Cadmium	ND	mg/L	0.0050
Iron	ND	mg/L	0.10
Zinc	ND	mg/L	0.051

MATRIX SPIKE/MATRIX SPIKE DUPLICATE QC REPORT  
Metals Analysis and Preparation  
Project: 049512

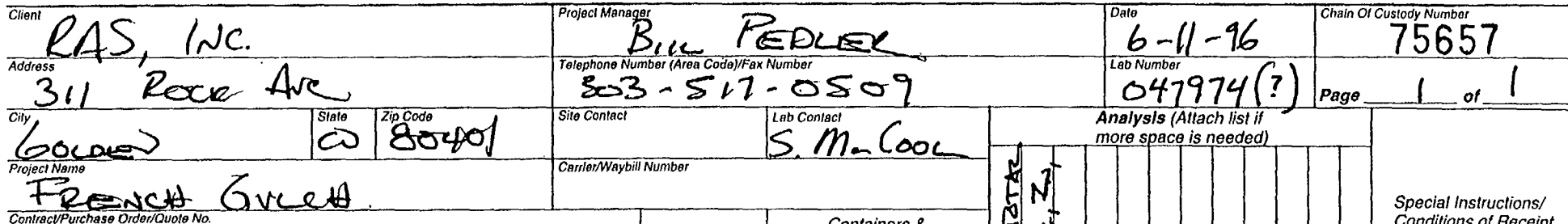
Category: ICP-AT ICP Metals / Total  
Matrix: AQUEOUS  
Sample: 049484-0001  
MS Run: 12 JUN 96-N1  
Units: mg/L

Analyte	Sample Result	Concentration		Amount Spiked		% Recovery		Recov. Accep.		RPD	
		MS Result	MSD Result	MS	MSD	MS	MSD	MSD Limits	MS-MSD	MSD Limit	RPD Accept
Aluminum	ND	2.2	2.2	2.0	2.0	108	110	80-120	1.1	20	
Antimony	ND	0.47	0.47	0.50	0.50	94	94	80-120	0.7	20	
Arsenic	ND	1.9	1.9	2.0	2.0	95	95	80-120	0.1	20	
Barium	ND	2.0	2.0	2.0	2.0	99	100	80-120	0.4	20	
Beryllium	ND	0.048	0.048	0.050	0.050	97	97	80-120	0.0	20	
Boron	NA	NA	NA	10	10	NC	NC	80-120	0.0	20	
Cadmium	ND	0.041	0.048	0.050	0.050	82	96	80-120	16	20	
Calcium	28	76	77	50	50	96	97	80-120	0.7	20	
Chromium	NA	NA	NA	0.20	0.20	NC	NC	80-120	0.0	20	
Cobalt	ND	0.48	0.49	0.50	0.50	97	98	80-120	1.5	20	
Copper	ND	0.25	0.25	0.25	0.25	100	100	80-120	0.4	20	
Iron	ND	1.1	1.1	1.0	1.0	107	108	80-120	1.3	20	
Lead	ND	0.48	0.47	0.50	0.50	97	94	80-120	2.5	20	
Lithium	NA	NA	NA	5.0	5.0	NC	NC	80-120	0.0	20	
Magnesium	11	59	60	50	50	97	98	80-120	0.8	20	
Manganese	ND	0.48	0.49	0.50	0.50	96	97	80-120	1.1	20	
Molybdenum	ND	NA	NA	0.50	0.50	NC	NC	80-120	0.0	20	
Nickel	ND	0.48	0.48	0.50	0.50	95	95	80-120	0.0	20	
Potassium	7.2	56	56	50	50	98	97	80-120	0.5	20	
Selenium	ND	2.1	2.1	2.0	2.0	105	104	80-120	1.3	20	
Silver	ND	0.050	0.050	0.050	0.050	100	99	80-120	0.9	20	
Sodium	120	170	170	50	50	94	96	80-120	0.7	20	
Thallium	ND	2.2	2.3	2.0	2.0	112	113	80-120	1.4	20	
Tin	NA	NA	NA	0.50	0.50	NC	NC	80-120	0.0	20	
Titanium	NA	NA	NA	0.50	0.50	NC	NC	80-120	0.0	20	
Vanadium	ND	0.50	0.50	0.50	0.50	99	100	80-120	0.6	20	
Zinc	ND	0.46	0.47	0.50	0.50	93	94	80-120	1.9	20	

NA = Not Applicable  
NC = Not Calculated, calculation not applicable.  
ND = Not Detected

Calculations are performed before rounding to avoid round-off errors in calculated results.

QUA-4124-1



Contract/Purchase Order/Quote No.			Matrix			Containers & Preservatives						Special Instructions/Conditions of Receipt																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
Sample I.D. No. and Description (Containers for each sample may be combined on one line)	Date	Time	Aqueous	Sed.	Soil	Unpres.	H2SO4	HNO3	HCl	NaOH	ZnAc2	NaOH																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		

### Possible Hazard Identification

☐ Non-Hazard    ☐ Flammable    ☐ Skin Irritant    ☐ Poison B    ☐ Unknown

### Sample Disposal

☐ *Return To Client*

☒ Disposal By Lab

☐ Archive For

\_\_\_\_ Months (A fee may be assessed if samples are retained longer than 3 months)

Turn Around Time Required

☐ 24 Hours ☒ 48 Hours ☐ 7 Days ☐ 14 Days ☐ 21 Days ☐ Other

QC Requirements (Specify)

1. Relinquished By \_\_\_\_\_ Date \_\_\_\_\_ Time \_\_\_\_\_

6-11-96

<div style="display: flex; justify-content: space-between;"> <div> <p>10/11/10</p> </div> <div> <p>10/11/10</p> </div> </div>	<div style="display: flex; justify-content: space-between;"> <div> <p>10/11/10</p> </div> <div> <p>10/11/10</p> </div> </div>
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2. Relinquished By \_\_\_\_\_ Date \_\_\_\_\_ Time \_\_\_\_\_

0			
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3. Relinquished By	Date	Time
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1. Received By

11/20/6	6/11/91	1240
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Approved By:	<i>[Signature]</i>	Date:	6/11/16	Page:	1210
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2. Received By		Date	Time
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[illegible]

3. Received By	Date	Time
----------------	------	------

### Comments

***This concludes the information  
associated with this section.***





Quanterra Incorporated  
4955 Yarrow Street  
Arvada, Colorado 80002

303 421-6611 Telephone  
303 431-7171 Fax

July 10, 1996

Mr. Bill Pedler  
R.A.S., Inc.  
311 Rock Avenue  
Golden, CO 80401

Dear Mr. Pedler:

Enclosed is the report for twelve aqueous samples received at Quanterra Environmental Services, Denver laboratory on June 28, 1996.

Included with the report is a quality control summary.

Please call if you have any questions.

Sincerely,

A handwritten signature in cursive script that reads "Susan H. McCool".

Susan H. McCool  
Project Administrator

Enclosures

Quanterra #049918

# Invoice



Environmental  
Services

Quanterra Environmental Services  
4955 Yarrow Street  
Arvada, CO 80002  
Tel: (303)421-6611  
Fax: (303)431-7171

Tel:  
Fax:

REMIT  
TO:

Quanterra, Incorporated  
P.O. Box 91501  
Chicago, IL 606931501

Number

Date

0028115237  
Quanterra Project Number

10 JUL 96  
Customer Number

RMAL-049918  
Terms

00374328

NET 30 DAYS

Customer Contact

Bill To:

Bill Pedler  
R.A.S. Inc.  
311 Rock Avenue  
Golden, CO 80401

Bill Pedler  
R.A.S. Inc.  
311 Rock Avenue  
Golden, CO 80401

Line No.	Qty.	Matrix Code	Analysis Description	Unit Price	Extended
1	12	AQUEOUS	ANALYTICAL SERVICES Method 6010 - ICP Metals (Total)	59.00	708.
			Analytical Services Subtotal	708.00	
			ADDITIONAL SERVICES		
			Additional Services Subtotal	0.00	

Customer P.O. Number / Contract Number / Reference

verbal per Bill Pedler

Quanterra Program Administrator

Salesperson

Susan McCool

Lisa Davis

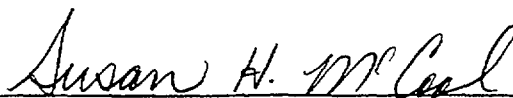
QUA-4027-B

Sub Total 708  
Tax  
Total 708

Federal Tax i D

ANALYTICAL RESULTS  
FOR  
R.A.S., Inc.  
FRENCH GULCH WATERSHEAD STUDY  
QUANTERRA ENVIRONMENTAL SERVICES  
DENVER NO. 049918  
JULY 10, 1996

Reviewed by:

  
Susan H. McCool

# Table Of Contents

## *Standard Deliverable*

### **Report Contents**

- Table of Contents
- Narrative
- LIMs Report Key
- Sample Description
- Test Requests
- Analytical Results
- QC Summary
- Chain-of-Custody
- Miscellaneous

**Total Number of Pages**

23

## **Introduction**

This report presents the analytical results as well as supporting information to aid in the evaluation and interpretation of the data and is arranged in the following order:

- o Sample Description Information
- o Analytical Test Requests
- o Analytical Results

All analyses at Quanterra are performed so that the maximum concentration of sample consistent with the method is analyzed. Dilutions are at times required to avoid saturation of the detector, to achieve linearity for a specific target compound, or to reduce matrix interferences. In this event, reporting limits are adjusted proportionately.

Samples 049918-0003 through -0006, -0008, and -0010 were analyzed at dilutions for method 6010 due to the elevated concentration of zinc in the samples. The reporting limits were raised relative to the dilutions required.

## **Sample Description Information**

The Sample Description Information lists all of the samples received in this project together with the internal laboratory identification number assigned for each sample. Each project received at Quanterra's Denver laboratory is assigned a unique six digit number. Samples within the project are numbered sequentially. The laboratory identification number is a combination of the six digit project code and the sample sequence number.

Also given in the Sample Description Information is the Sample Type (matrix), Date of Sampling (if known) and Date of Receipt at the laboratory.

## **Analytical Test Requests**

The Analytical Test Requests lists the analyses that were performed on each sample. The Custom Test column indicates where tests have been modified to conform to the specific requirements of this project.

## LIMs Report Key

Section	Description
Cover Letter	Signature page, report narrative as applicable.
Sample Description Information	Tabulated cross-reference between the Lab ID and Client ID, including matrix, date and time sampled, and the date received for all samples in the project.
Sample Analysis Results Sheets	Lists sample results, test components, reporting limits, dates prepared and analyzed, and any data qualifiers. Pages are organized by test.
QC LOT Assignment Report	Cross-reference between lab IDs and applicable QC batches (DCS, LCS, Blank, MS/SD, DU)
Duplicate Control Sample Report	Percent recovery and RPD results, with acceptance limits, for the laboratory duplicate control samples for each test are tabulated in this report. These are measures of accuracy and precision for each test. Acceptance limits are based upon laboratory historical data.
Laboratory Control Sample Report	Percent recovery results for a single Laboratory Control Sample (if applicable) are tabulated in this report, with the applicable acceptance limits for each test.
Matrix Spike/Matrix Spike Duplicate Report	Percent recovery and RPD results for matrix-specific QC samples and acceptance limits, where applicable. This report can be used to assess matrix effects on an analysis.
Single Control Sample Report	A tabulation of the surrogate recoveries for the blank for organic analyses.
Method Blank Report	A summary of the results of the analysis of the method blank for each test.

## List of Abbreviations and Terms

Abbreviation	Term	Abbreviation	Term
DCS	Duplicate Control Sample	MSD	Matrix Spike Duplicate
DU	Sample Duplicate	QC Run	Preparation Batch
EB	Equipment Blank	QC Category	LIMs QC Category
FB	Field Blank	QC Lot	DCS Batch
FD	Field Duplicate	ND	Not Detected at or above the reporting limit expressed
IDL	Instrument Detection Limit (Metals)	QC Matrix	Matrix of the laboratory control sample(s)
LCS	Laboratory Control Sample	RL	Reporting Limit
MB	Method Blank	QC	Quality Control
MDL	Method Detection Limit	SA	Sample
MS	Matrix Spike	SD	Spike Duplicate
RPD	Relative Percent Difference	TB	Trip Blank
ppm (part-per-million)	mg/L or mg/kg (usually)	ppb (part-per-billion)	ug/L or ug/kg (usually)
QUAL	Qualifier flag	DIL	Dilution Factor

SAMPLE DESCRIPTION INFORMATION  
for  
R.A.S. Inc.

Lab ID	Client ID	Matrix	Sampled Date	Time	Received Date
049918-0001-SA	FG0023	AQUEOUS	27 JUN 96		28 JUN 96
049918-0002-SA	FG0024	AQUEOUS	27 JUN 96		28 JUN 96
049918-0003-SA	FG0025	AQUEOUS	27 JUN 96		28 JUN 96
049918-0004-SA	FG0026	AQUEOUS	27 JUN 96		28 JUN 96
049918-0005-SA	FG0027	AQUEOUS	27 JUN 96		28 JUN 96
049918-0006-SA	FG0028	AQUEOUS	27 JUN 96		28 JUN 96
049918-0007-SA	FG0029	AQUEOUS	27 JUN 96		28 JUN 96
049918-0008-SA	FG0030	AQUEOUS	27 JUN 96		28 JUN 96
049918-0009-SA	FG0031	AQUEOUS	27 JUN 96		28 JUN 96
049918-0010-SA	FG0032	AQUEOUS	27 JUN 96		28 JUN 96
049918-0011-SA	FG0033	AQUEOUS	27 JUN 96		28 JUN 96
049918-0012-SA	FG0034	AQUEOUS	27 JUN 96		28 JUN 96

ANALYTICAL TEST REQUESTS  
for  
R.A.S. Inc.

Lab ID: 049918	Group Code	Analysis Description	Custom Test?
0001 - 0012	A	ICP Metals (Total) Prep - Total Metals, ICP	Y N



## Analytical Results

The analytical results for this project are presented in the following data tables. Each data table includes sample identification information, and when available and appropriate, dates sampled, received, authorized, prepared and analyzed. The authorization data is the date when the project was defined by the client such that laboratory work could begin.

Data sheets contain a listing of the parameters measured in each test, the analytical results and the Quanterra reporting limit. Reporting limits are adjusted to reflect dilution of the sample, when appropriate.

The results from the Standard Quanterra QA/QC Program, which generates data which are independent of matrix effects, are provided subsequently.

**Metals****Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0023  
Lab ID: 049918-0001-SA  
Matrix: AQUEOUS  
Authorized: 28 JUN 96

Sampled: 27 JUN 96  
Prepared: See Below

Received: 28 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	ND	mg/L	0.0050	6010	01 JUL 96	03 JUL 96
Iron	ND	mg/L	0.10	6010	01 JUL 96	03 JUL 96
Zinc	ND	mg/L	0.051	6010	01 JUL 96	03 JUL 96

ND = Not detected  
NA = Not applicable

Reported By: Doug Gomer

Approved By: Richard Persichitte

**Metals****Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0024  
Lab ID: 049918-0002-SA  
Matrix: AQUEOUS  
Authorized: 28 JUN 96

Sampled: 27 JUN 96  
Prepared: See Below

Received: 28 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.0075	mg/L	0.0050	6010	01 JUL 96	03 JUL 96
Iron	15.7	mg/L	0.10	6010	01 JUL 96	03 JUL 96
Zinc	4.3	mg/L	0.051	6010	01 JUL 96	03 JUL 96

ND = Not detected  
NA = Not applicable

Reported By: Doug Gomer

Approved By: Richard Persichitte

Metals

Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0025  
Lab ID: 049918-0003-SA  
Matrix: AQUEOUS  
Authorized: 28 JUN 96

Sampled: 27 JUN 96  
Prepared: See Below

Received: 28 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	15.2	mg/L	0.25	6010	01 JUL 96	03 JUL 96
Iron	3750	mg/L	5.0	6010	01 JUL 96	03 JUL 96
Zinc	3360	mg/L	2.5	6010	01 JUL 96	03 JUL 96

ND = Not detected  
NA = Not applicable

Reported By: Doug Gomer

Approved By: Richard Persichitte

**Metals****Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0026  
Lab ID: 049918-0004-SA  
Matrix: AQUEOUS  
Authorized: 28 JUN 96

Sampled: 27 JUN 96  
Prepared: See Below

Received: 28 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.092	mg/L	0.010	6010	01 JUL 96	03 JUL 96
Iron	117	mg/L	0.20	6010	01 JUL 96	03 JUL 96
Zinc	124	mg/L	0.10	6010	01 JUL 96	03 JUL 96

ND = Not detected  
NA = Not applicable

Reported By: Doug Gomer

Approved By: Richard Persichitte

Metals

Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0027  
Lab ID: 049918-0005-SA  
Matrix: AQUEOUS  
Authorized: 28 JUN 96

Sampled: 27 JUN 96  
Prepared: See Below

Received: 28 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.72	mg/L	0.025	6010	01 JUL 96	03 JUL 96
Iron	184	mg/L	0.50	6010	01 JUL 96	03 JUL 96
Zinc	242	mg/L	0.25	6010	01 JUL 96	03 JUL 96

ND = Not detected  
NA = Not applicable

Reported By: Doug Gomer

Approved By: Richard Persichitte

**Metals****Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0028  
Lab ID: 049918-0006-SA  
Matrix: AQUEOUS  
Authorized: 28 JUN 96

Sampled: 27 JUN 96  
Prepared: See Below

Received: 28 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.31	mg/L	0.025	6010	01 JUL 96	03 JUL 96
Iron	279	mg/L	0.50	6010	01 JUL 96	03 JUL 96
Zinc	256	mg/L	0.25	6010	01 JUL 96	03 JUL 96

ND = Not detected  
NA = Not applicable

Reported By: Doug Gomer

Approved By: Richard Persichitte

Metals

Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0029  
Lab ID: 049918-0007-SA  
Matrix: AQUEOUS  
Authorized: 28 JUN 96

Sampled: 27 JUN 96  
Prepared: See Below

Received: 28 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.011	mg/L	0.0050	6010	01 JUL 96	03 JUL 96
Iron	11.2	mg/L	0.10	6010	01 JUL 96	03 JUL 96
Zinc	7.9	mg/L	0.051	6010	01 JUL 96	03 JUL 96

ND = Not detected  
NA = Not applicable

Reported By: Doug Gomer

Approved By: Richard Persichitte



**Metals**

**Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0030  
Lab ID: 049918-0008-SA  
Matrix: AQUEOUS  
Authorized: 28 JUN 96

Sampled: 27 JUN 96  
Prepared: See Below

Received: 28 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.68	mg/L	0.025	6010	01 JUL 96	03 JUL 96
Iron	164	mg/L	0.50	6010	01 JUL 96	03 JUL 96
Zinc	232	mg/L	0.25	6010	01 JUL 96	03 JUL 96

ND = Not detected  
NA = Not applicable

Reported By: Doug Gomer

Approved By: Richard Persichitte

Metals

Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0031  
Lab ID: 049918-0009-SA  
Matrix: AQUEOUS  
Authorized: 28 JUN 96

Sampled: 27 JUN 96  
Prepared: See Below

Received: 28 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	ND	mg/L	0.0050	6010	01 JUL 96	03 JUL 96
Iron	0.18	mg/L	0.10	6010	01 JUL 96	03 JUL 96
Zinc	<del>ND</del>	mg/L	<del>0.051</del>	6010	01 JUL 96	03 JUL 96

0.048

0.020 ±

\* REVISED BY LAB  
7-31-96  
WAP

ND = Not detected  
NA = Not applicable

Reported By: Doug Gomer

Approved By: Richard Persichitte

**Metals****Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0032  
Lab ID: 049918-0010-SA  
Matrix: AQUEOUS  
Authorized: 28 JUN 96

Sampled: 27 JUN 96  
Prepared: See Below

Received: 28 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.61	mg/L	0.025	6010	01 JUL 96	03 JUL 96
Iron	163	mg/L	0.50	6010	01 JUL 96	03 JUL 96
Zinc	328	mg/L	0.25	6010	01 JUL 96	03 JUL 96

ND = Not detected  
NA = Not applicable

Reported By: Doug Gomer

Approved By: Richard Persichitte

**Metals**

**Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0033  
Lab ID: 049918-0011-SA  
Matrix: AQUEOUS  
Authorized: 28 JUN 96

Sampled: 27 JUN 96  
Prepared: See Below

Received: 28 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	0.0074	mg/L	0.0050	6010	01 JUL 96	03 JUL 96
Iron	0.28	mg/L	0.10	6010	01 JUL 96	03 JUL 96
Zinc	2.7	mg/L	0.051	6010	01 JUL 96	03 JUL 96

ND = Not detected  
NA = Not applicable

Reported By: Doug Gomer

Approved By: Richard Persichitte

Metals

Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0034  
Lab ID: 049918-0012-SA  
Matrix: AQUEOUS  
Authorized: 28 JUN 96

Sampled: 27 JUN 96  
Prepared: See Below

Received: 28 JUN 96  
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Cadmium	ND	mg/L	0.0050	6010	01 JUL 96	03 JUL 96
Iron	0.13	mg/L	0.10	6010	01 JUL 96	03 JUL 96
Zinc	0.66	mg/L	0.051	6010	01 JUL 96	03 JUL 96

ND = Not detected  
NA = Not applicable

Reported By: Doug Gomer

Approved By: Richard Persichitte

QC LOT ASSIGNMENT REPORT  
Metals Analysis and Preparation

Laboratory Sample Number	QC Matrix	QC Category	QC Lot Number (DCS)	QC Run Number (SCS/BLANK)
049918-0001-SA	AQUEOUS	ICP-AT	01 JUL 96-MM	01 JUL 96-MM
049918-0002-SA	AQUEOUS	ICP-AT	01 JUL 96-MM	01 JUL 96-MM
049918-0003-SA	AQUEOUS	ICP-AT	01 JUL 96-MM	01 JUL 96-MM
049918-0004-SA	AQUEOUS	ICP-AT	01 JUL 96-MM	01 JUL 96-MM
049918-0005-SA	AQUEOUS	ICP-AT	01 JUL 96-MM	01 JUL 96-MM
049918-0006-SA	AQUEOUS	ICP-AT	01 JUL 96-MM	01 JUL 96-MM
049918-0007-SA	AQUEOUS	ICP-AT	01 JUL 96-MM	01 JUL 96-MM
049918-0008-SA	AQUEOUS	ICP-AT	01 JUL 96-MM	01 JUL 96-MM
049918-0009-SA	AQUEOUS	ICP-AT	01 JUL 96-MM	01 JUL 96-MM
049918-0010-SA	AQUEOUS	ICP-AT	01 JUL 96-MM	01 JUL 96-MM
049918-0011-SA	AQUEOUS	ICP-AT	01 JUL 96-MM	01 JUL 96-MM
049918-0012-SA	AQUEOUS	ICP-AT	01 JUL 96-MM	01 JUL 96-MM

LABORATORY CONTROL SAMPLE REPORT  
Metals Analysis and Preparation

Analyte	Concentration		Accuracy(%)	
	Spiked	Measured	LCS	Limits
Category: ICP-AT				
Matrix: AQUEOUS				
QC Lot: 01 JUL 96-MM      QC Run: 01 JUL 96-MM				
Concentration Units: mg/L				
Aluminum	2.00	2.08	104	80-116
Antimony	0.500	0.489	98	80-115
Arsenic	2.00	2.00	100	80-115
Barium	2.00	2.01	100	80-114
Beryllium	0.0500	0.0503	101	80-120
Boron	1.00	1.04	104	80-120
Cadmium	0.500	0.493	99	80-119
Calcium	50.0	51.8	104	80-114
Chromium	0.200	0.188	94	80-116
Cobalt	0.500	0.504	101	80-114
Copper	0.250	0.251	100	80-120
Iron	1.00	1.03	103	80-120
Lead	0.500	0.488	98	80-119
Lithium	1.00	0.881	88	80-120
Magnesium	50.0	51.8	104	81-120
Manganese	0.500	0.502	100	80-116
Molybdenum	1.00	0.960	96	80-120
Nickel	0.500	0.495	99	80-114
Potassium	50.0	51.0	102	80-120
Selenium	2.00	2.03	102	80-120
Silver	0.0500	0.0517	103	80-119
Sodium	50.0	52.8	106	80-120
Tin	2.00	1.83	92	80-120
Titanium	1.00	0.954	95	80-120
Vanadium	0.500	0.499	100	80-116
Zinc	0.500	0.491	98	80-120

Calculations are performed before rounding to avoid round-off errors in calculated results.

METHOD BLANK REPORT  
Metals Analysis and Preparation

Analyte	Result	Units	Reporting Limit
Test: ICP-AT			
Matrix: AQUEOUS			
QC Lot: 01 JUL 96-MM QC Run: 01 JUL 96-MM			
Cadmium	ND	mg/L	0.0050
Iron	ND	mg/L	0.10
Zinc	ND	mg/L	0.051



MATRIX SPIKE/MATRIX SPIKE DUPLICATE QC REPORT  
Metals Analysis and Preparation  
Project: 049918

Category: ICP-AT ICP Metals / Total  
Matrix: AQUEOUS  
Sample: 049918-0012  
MS Run: 01 JUL 96-MM  
Units: mg/L

Analyte	Sample Result	Concentration		Amount Spiked		% Recovery		Recov. Accep. Limits	RPD MS-MSD	RPD Accep. Limit
		MS Result	MSD Result	MS	MSD	MS	MSD			
Aluminum	0.064	2.1	2.1	2.0	2.0	104	103	80-120	1.0	
Antimony	NA	NA	NA	0.50	0.50	NC	NC	80-120	0.0	
Arsenic	NA	NA	NA	0.50	0.50	NC	NC	80-120	0.0	
Barium	0.010	2.0	2.0	2.0	2.0	98	98	80-120	0.0	
Beryllium	ND	0.050	0.050	0.050	0.050	101	100	80-120	0.9	
Boron	NA	NA	NA	10	10	NC	NC	80-120	0.0	
Cadmium	ND	0.047	0.051	0.050	0.050	95	103	80-120	8.3	
Calcium	18	69	69	50	50	101	100	80-120	0.3	
Chromium	ND	0.18	0.19	0.20	0.20	91	93	80-120	1.7	
Cobalt	ND	0.49	0.49	0.50	0.50	98	98	80-120	0.6	
Copper	ND	0.25	0.25	0.25	0.25	101	100	80-120	0.5	
Iron	0.13	1.1	1.1	1.0	1.0	101	99	80-120	1.9	
Lead	NA	NA	NA	0.50	0.50	NC	NC	80-120	0.0	
Lithium	NA	NA	NA	5.0	5.0	NC	NC	80-120	0.0	
Magnesium	2.2	52	53	50	50	101	101	80-120	0.2	
Manganese	0.066	0.54	0.55	0.50	0.50	95	96	80-120	0.8	
Molybdenum	ND	0.94	0.94	1.0	0.50	94	189	80-120	0.5	
Nickel	ND	0.48	0.48	0.50	0.50	95	97	80-120	1.9	
Potassium	ND	51	51	50	50	103	102	80-120	0.7	
Selenium	NA	NA	NA	0.50	0.50	NC	NC	80-120	0.0	
Silver	ND	0.050	0.051	0.050	0.050	100	102	80-120	2.0	
Sodium	ND	53	54	50	50	107	108	80-120	1.2	
Thallium	NA	NA	NA	5.0	5.0	NC	NC	80-120	0.0	
Tin	NA	NA	NA	0.50	0.50	NC	NC	80-120	0.0	
Titanium	NA	NA	NA	0.50	0.50	NC	NC	80-120	0.0	
Vanadium	ND	0.49	0.49	0.50	0.50	98	97	80-120	0.8	
Zinc	0.66	1.1	1.1	0.50	0.50	90	91	80-120	0.4	

NA = Not Applicable  
NC = Not Calculated, calculation not applicable.  
ND = Not Detected

Calculations are performed before rounding to avoid round-off errors in calculated results.



Quanterra Incorporated  
4955 Yarrow Street  
Arvada, Colorado 80002

303 421-6611 Telephone  
303 431-7171 Fax

July 30, 1996

Mr. Bill Pedler  
R.A.S., Inc.  
311 Rock Avenue  
Golden, CO 80401

Dear Mr. Pedler:

Enclosed is the report for eleven aqueous samples received at Quanterra Environmental Services, Denver laboratory on July 23, 1996.

Included with the report is a quality control summary.

Please call if you have any questions.

Sincerely,

A handwritten signature in cursive script that reads "Susan H. McCool".

Susan H. McCool  
Project Administrator

Enclosures

Quanterra #050360

# Invoice



Environmental  
Services

Quanterra Environmental Services  
4955 Yarrow Street  
Arvada, CO 80002  
Tel: (303) 421-6611  
Fax: (303) 431-7171

Tel:

Fax:

REMIT  
TO:

Quanterra, Incorporated  
P.O. Box 91501  
Chicago, IL 606931501

Number

Date

0028115738  
Quanterra Project Number

30 JUL 96  
Customer Number

RMAL-050360  
Terms

00374328

NET 30 DAYS

Customer Contact

Bill To:

Bill Pedler  
R.A.S. Inc.  
311 Rock Avenue  
Golden, CO 80401

Bill Pedler  
R.A.S. Inc.  
311 Rock Avenue  
Golden, CO 80401

Line No.	Qty.	Matrix Code	Analysis Description	Unit Price	Extended Price
1	11	AQUEOUS	ANALYTICAL SERVICES Method 6010 - ICP Metals (Total)	59.00	649.00
			Analytical Services Subtotal	649.00	
			ADDITIONAL SERVICES		
			Additional Services Subtotal	0.00	

Customer P.O. Number: Contract Number: Reference

verbal per Bill Pedler  
Quanterra Project Manager

Salesperson

Susan McCool  
QUA-4027-C

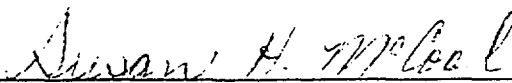
Lisa Davis

Sub Total 649.00  
Tax  
Total 649.00

Federal Tax 0.00

ANALYTICAL RESULTS  
FOR  
R.A.S., Inc.  
FRENCH GULCH WATERSHEAD STUDY  
QUANTERRA ENVIRONMENTAL SERVICES  
DENVER NO. 050360  
JULY 30, 1996

Reviewed by:



Susan H. McCool

# **Table Of Contents**

## ***Standard Deliverable***

### **Report Contents**

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- Narrative
- LIMs Report Key
- Sample Description
- Test Requests
- Analytical Results
- QC Summary
- Chain-of-Custody
- Miscellaneous

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## Introduction

This report presents the analytical results as well as supporting information to aid in the evaluation and interpretation of the data and is arranged in the following order:

- o Sample Description Information
- o Analytical Test Requests
- o Analytical Results

All analyses at Quanterra are performed so that the maximum concentration of sample consistent with the method is analyzed. Dilutions are at times required to avoid saturation of the detector, to achieve linearity for a specific target compound, or to reduce matrix interferences. In this event, reporting limits are adjusted proportionately.

Samples 050360-0001, -0004 through -0006, and -0009 were analyzed at dilutions for method 6010 due to the elevated concentration of zinc in the samples. The reporting limits were raised relative to the dilutions required.

The recoveries for iron and zinc were not calculable in the matrix specific batch QC due to the elevated concentrations of these analytes in the spiked sample. The recoveries are reported as "NC".

## Sample Description

The Sample Description Information lists all of the samples received in this project together with the internal laboratory identification number assigned for each sample. Each project received at Quanterra's Denver laboratory is assigned a unique six digit number. Samples within the project are numbered sequentially. The laboratory identification number is a combination of the six digit project code and the sample sequence number.

Also given in the Sample Description Information is the Sample Type (matrix), Date of Sampling (if known) and Date of Receipt at the laboratory.

## Analytical Test Requests

The Analytical Test Requests lists the analyses that were performed on each sample. The Custom Test column indicates where tests have been modified to conform to the specific requirements of this project.

## LIMs Report Key

Section	Description
Cover Letter	Signature page, report narrative as applicable.
Sample Description Information	Tabulated cross-reference between the Lab ID and Client ID, including matrix, date and time sampled, and the date received for all samples in the project.
Sample Analysis Results Sheets	Lists sample results, test components, reporting limits, dates prepared and analyzed, and any data qualifiers. Pages are organized by test.
QC LOT Assignment Report	Cross-reference between lab IDs and applicable QC batches (DCS, LCS, Blank, MS/SD, DU)
Duplicate Control Sample Report	Percent recovery and RPD results, with acceptance limits, for the laboratory duplicate control samples for each test are tabulated in this report. These are measures of accuracy and precision for each test. Acceptance limits are based upon laboratory historical data.
Laboratory Control Sample Report	Percent recovery results for a single Laboratory Control Sample (if applicable) are tabulated in this report, with the applicable acceptance limits for each test.
Matrix Spike/Matrix Spike Duplicate Report	Percent recovery and RPD results for matrix-specific QC samples and acceptance limits, where applicable. This report can be used to assess matrix effects on an analysis.
Single Control Sample Report	A tabulation of the surrogate recoveries for the blank for organic analyses.
Method Blank Report	A summary of the results of the analysis of the method blank for each test.

## List of Abbreviations and Terms

Abbreviation	Term	Abbreviation	Term
DCS	Duplicate Control Sample	MSD	Matrix Spike Duplicate
DU	Sample Duplicate	QC Run	Preparation Batch
EB	Equipment Blank	QC Category	LIMs QC Category
FB	Field Blank	QC Lot	DCS Batch
FD	Field Duplicate	ND	Not Detected at or above the reporting limit expressed
IDL	Instrument Detection Limit (Metals)	QC Matrix	Matrix of the laboratory control sample(s)
LCS	Laboratory Control Sample	RL	Reporting Limit
MB	Method Blank	QC	Quality Control
MDL	Method Detection Limit	SA	Sample
MS	Matrix Spike	SD	Spike Duplicate
RPD	Relative Percent Difference	TB	Trip Blank
ppm (part-per-million)	mg/L or mg/kg (usually)	ppb (part-per-billion)	ug/L or ug/kg (usually)
QUAL	Qualifier flag	DIL	Dilution Factor

SAMPLE DESCRIPTION INFORMATION  
for  
R.A.S. Inc.

Lab ID	Client ID	Matrix	Sampled Date	Time	Received Date
050360-0001-SA	FG0035(MW-3)	AQUEOUS	22 JUL 96		23 JUL 96
050360-0002-SA	FG0036(MW-9)	AQUEOUS	22 JUL 96		23 JUL 96
050360-0003-SA	FG0037(MW-14)	AQUEOUS	22 JUL 96		23 JUL 96
050360-0004-SA	FG0038(MW-16)	AQUEOUS	22 JUL 96		23 JUL 96
050360-0005-SA	FG0039(#3 RELIEF WELL)	AQUEOUS	22 JUL 96		23 JUL 96
050360-0006-SA	FG0040(RF-3)	AQUEOUS	22 JUL 96		23 JUL 96
050360-0007-SA	FG0041(KDS)	AQUEOUS	22 JUL 96		23 JUL 96
050360-0008-SA	FG0042(FC@CB)	AQUEOUS	22 JUL 96		23 JUL 96
050360-0009-SA	FG0043(6C)	AQUEOUS	22 JUL 96		23 JUL 96
050360-0010-SA	FG0044(FG-7)	AQUEOUS	22 JUL 96		23 JUL 96
050360-0011-SA	FG0045(FG-8)	AQUEOUS	22 JUL 96		23 JUL 96



ANALYTICAL TEST REQUESTS  
for  
R.A.S. Inc.

Lab ID: 050360	Group Code	Analysis Description	Custom Test?
0001 - 0011	A	ICP Metals (Total) Prep - Total Metals, ICP	Y N

## Analytical Results

The analytical results for this project are presented in the following data tables. Each data table includes sample identification information, and when available and appropriate, dates sampled, received, authorized, prepared and analyzed. The authorization data is the date when the project was defined by the client such that laboratory work could begin.

Data sheets contain a listing of the parameters measured in each test, the analytical results and the Quanterra reporting limit. Reporting limits are adjusted to reflect dilution of the sample, when appropriate.

The results from the Standard Quanterra QA/QC Program, which generates data which are independent of matrix effects, are provided subsequently.

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0035(MW-3)  
Lab ID: 050360-0001-SA  
Matrix: AQUEOUS  
Authorized: 23 JUL 96

Sampled: 22 JUL 96  
Prepared: See Below

Received: 23 JUL 96  
Analyzed: See Below

Parameter	Result Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.17	5.0	0.025	mg/L	6010	27 JUL 96	29 JUL 96
Iron	338	5.0	0.50	mg/L	6010	27 JUL 96	29 JUL 96
Zinc	243	5.0	0.10	mg/L	6010	27 JUL 96	29 JUL 96

Reported By: Doug Gomer

Approved By: Kristina Sanchez

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0036(MW-9)  
Lab ID: 050360-0002-SA  
Matrix: AQUEOUS  
Authorized: 23 JUL 96

Sampled: 22 JUL 96  
Prepared: See Below

Received: 23 JUL 96  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	ND		1.0	0.0050	mg/L	6010	27 JUL 96	29 JUL 96
Iron	0.51		1.0	0.10	mg/L	6010	27 JUL 96	29 JUL 96
Zinc	0.17		1.0	0.020	mg/L	6010	27 JUL 96	29 JUL 96

ND = Not Detected

Reported By: Doug Gomer

Approved By: Kristina Sanchez

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0037(MW-14)  
Lab ID: 050360-0003-SA  
Matrix: AQUEOUS  
Authorized: 23 JUL 96

Sampled: 22 JUL 96  
Prepared: See Below

Received: 23 JUL 96  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	ND		1.0	0.0050	mg/L	6010	27 JUL 96	29 JUL 96
Iron	15.1		1.0	0.10	mg/L	6010	27 JUL 96	29 JUL 96
Zinc	4.6		1.0	0.020	mg/L	6010	27 JUL 96	29 JUL 96

ND = Not Detected

Reported By: Doug Gomer

Approved By: Kristina Sanchez

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0038(MW-16)  
Lab ID: 050360-0004-SA  
Matrix: AQUEOUS  
Authorized: 23 JUL 96

Sampled: 22 JUL 96  
Prepared: See Below

Received: 23 JUL 96  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.058		2.0	0.010	mg/L	6010	27 JUL 96	29 JUL 96
Iron	94.5		2.0	0.20	mg/L	6010	27 JUL 96	29 JUL 96
Zinc	106		2.0	0.040	mg/L	6010	27 JUL 96	29 JUL 96

Reported By: Doug Gomer

Approved By: Kristina Sanchez

**Metals  
Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0039(#3 RELIEF WELL)  
Lab ID: 050360-0005-SA  
Matrix: AQUEOUS  
Authorized: 23 JUL 96

Sampled: 22 JUL 96  
Prepared: See Below

Received: 23 JUL 96  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.53		2.0	0.010	mg/L	6010	27 JUL 96	29 JUL 96
Iron	144		2.0	0.20	mg/L	6010	27 JUL 96	29 JUL 96
Zinc	199		2.0	0.040	mg/L	6010	27 JUL 96	29 JUL 96

Reported By: Doug Gomer

Approved By: Kristina Sanchez

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0040(RF-3)  
Lab ID: 050360-0006-SA  
Matrix: AQUEOUS  
Authorized: 23 JUL 96

Sampled: 22 JUL 96  
Prepared: See Below

Received: 23 JUL 96  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	13.6		50	0.25	mg/L	6010	27 JUL 96	29 JUL 96
Iron	3940		50	5.0	mg/L	6010	27 JUL 96	29 JUL 96
Zinc	3260		50	1.0	mg/L	6010	27 JUL 96	29 JUL 96

Reported By: Doug Gomer

Approved By: Kristina Sanchez



Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0041(KDS)  
Lab ID: 050360-0007-SA  
Matrix: AQUEOUS  
Authorized: 23 JUL 96

Sampled: 22 JUL 96  
Prepared: See Below

Received: 23 JUL 96  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	ND		1.0	0.0050	mg/L	6010	27 JUL 96	29 JUL 96
Iron	2.8		1.0	0.10	mg/L	6010	27 JUL 96	29 JUL 96
Zinc	6.1		1.0	0.020	mg/L	6010	27 JUL 96	29 JUL 96

ND = Not Detected

Reported By: Doug Gomer

Approved By: Kristina Sanchez

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0042(FC@CB)  
Lab ID: 050360-0008-SA  
Matrix: AQUEOUS  
Authorized: 23 JUL 96

Sampled: 22 JUL 96  
Prepared: See Below

Received: 23 JUL 96  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	ND		1.0	0.0050	mg/L	6010	27 JUL 96	29 JUL 96
Iron	ND		1.0	0.10	mg/L	6010	27 JUL 96	29 JUL 96
Zinc	0.025		1.0	0.020	mg/L	6010	27 JUL 96	29 JUL 96

ND = Not Detected

Reported By: Doug Gomer

Approved By: Kristina Sanchez

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0043(6C)  
Lab ID: 050360-0009-SA  
Matrix: AQUEOUS  
Authorized: 23 JUL 96

Sampled: 22 JUL 96  
Prepared: See Below

Received: 23 JUL 96  
Analyzed: See Below

Parameter	Result-Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.34	5.0	0.025	mg/L	6010	27 JUL 96	29 JUL 96
Iron	334	5.0	0.50	mg/L	6010	27 JUL 96	29 JUL 96
Zinc	285	5.0	0.10	mg/L	6010	27 JUL 96	29 JUL 96

Reported By: Doug Gomer

Approved By: Kristina Sanchez

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0044 (FG-7)  
Lab ID: 050360-0010-SA  
Matrix: AQUEOUS  
Authorized: 23 JUL 96

Sampled: 22 JUL 96  
Prepared: See Below

Received: 23 JUL 96  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.0073		1.0	0.0050	mg/L	6010	27 JUL 96	29 JUL 96
Iron	0.27		1.0	0.10	mg/L	6010	27 JUL 96	29 JUL 96
Zinc	4.2		1.0	0.020	mg/L	6010	27 JUL 96	29 JUL 96

Reported By: Doug Gomer

Approved By: Kristina Sanchez

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0045(FG-8)  
Lab ID: 050360-0011-SA  
Matrix: AQUEOUS  
Authorized: 23 JUL 96

Sampled: 22 JUL 96  
Prepared: See Below

Received: 23 JUL 96  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	ND		1.0	0.0050	mg/L	6010	27 JUL 96	29 JUL 96
Iron	0.13		1.0	0.10	mg/L	6010	27 JUL 96	29 JUL 96
Zinc	0.59		1.0	0.020	mg/L	6010	27 JUL 96	29 JUL 96

ND = Not Detected

Reported By: Doug Gomer

Approved By: Kristina Sanchez

QC LOT ASSIGNMENT REPORT  
Metals Analysis and Preparation

Laboratory Sample Number	QC Matrix	QC Category	QC Lot Number (DCS)	QC Run Number (SCS/BLANK)
050360-0001-SA	AQUEOUS	ICP-AT	27 JUL 96-A1	27 JUL 96-A1
050360-0002-SA	AQUEOUS	ICP-AT	27 JUL 96-A1	27 JUL 96-A1
050360-0003-SA	AQUEOUS	ICP-AT	27 JUL 96-A1	27 JUL 96-A1
050360-0004-SA	AQUEOUS	ICP-AT	27 JUL 96-A1	27 JUL 96-A1
050360-0005-SA	AQUEOUS	ICP-AT	27 JUL 96-A1	27 JUL 96-A1
050360-0006-SA	AQUEOUS	ICP-AT	27 JUL 96-A1	27 JUL 96-A1
050360-0007-SA	AQUEOUS	ICP-AT	27 JUL 96-A1	27 JUL 96-A1
050360-0008-SA	AQUEOUS	ICP-AT	27 JUL 96-A1	27 JUL 96-A1
050360-0009-SA	AQUEOUS	ICP-AT	27 JUL 96-A1	27 JUL 96-A1
050360-0010-SA	AQUEOUS	ICP-AT	27 JUL 96-A1	27 JUL 96-A1
050360-0011-SA	AQUEOUS	ICP-AT	27 JUL 96-A1	27 JUL 96-A1

LABORATORY CONTROL SAMPLE REPORT  
Metals Analysis and Preparation

Analyte	Concentration		Accuracy(%)	
	Spiked	Measured	LCS	Limits
Category: ICP-AT				
Matrix: AQUEOUS				
QC Lot: 27 JUL 96-A1      QC Run: 27 JUL 96-A1				
Concentration Units: mg/L				
Aluminum	2.00	2.00	100	80-116
Antimony	0.500	0.470	94	80-115
Arsenic	2.00	1.76	88	80-115
Barium	2.00	1.91	95	80-114
Beryllium	0.0500	0.0485	97	80-120
Boron	1.00	1.04	104	80-120
Cadmium	0.0500	0.0437	87	80-119
Calcium	50.0	48.5	97	80-114
Chromium	0.200	0.182	91	80-116
Cobalt	0.500	0.473	95	80-114
Copper	0.250	0.242	97	80-120
Iron	1.00	0.958	96	80-120
Lead	0.500	0.480	96	80-119
Lithium	1.00	0.866	87	80-120
Magnesium	50.0	48.7	97	81-120
Manganese	0.500	0.478	96	80-116
Molybdenum	1.00	0.947	95	80-120
Nickel	0.500	0.459	92	80-114
Potassium	50.0	47.7	95	80-120
Selenium	2.00	1.89	95	80-120
Silver	0.0500	0.0459	92	80-119
Sodium	50.0	50.8	102	80-120
Tin	2.00	1.89	94	80-120
Titanium	1.00	0.997	100	80-120
Vanadium	0.500	0.480	96	80-116
Zinc	0.500	0.442	88	80-120

METHOD BLANK REPORT  
Metals Analysis and Preparation

Analyte	Result	Units	Reporting Limit
Test: ICP-AT			
Matrix: AQUEOUS			
QC Lot: 27 JUL 96-A1 QC Run: 27 JUL 96-A1			
Cadmium	ND	mg/L	0.0050
Iron	ND	mg/L	0.10
Zinc	ND	mg/L	0.020



MATRIX SPIKE/MATRIX SPIKE DUPLICATE QC REPORT  
Metals Analysis and Preparation  
Project: 050360

Category: ICP-AT ICP Metals / Total  
Matrix: AQUEOUS  
Sample: 050360-0001  
MS Run: 27 JUL 96-A1  
Units: mg/L

Analyte	Concentration			Amount Spiked		% Recovery		Recov. Accep.	RPD	Accept
	Sample Result	MS Result	MSD Result	MS MSD		MS MSD		Limits	MS-MSD	Limits
Aluminum	ND	2.1	2.0	2.0	2.0	103	99	80-120	4.4	20
Antimony	ND	0.49	0.46	0.50	0.50	99	93	80-120	6.3	20
Arsenic	NA	NA	NA	2.0	2.0	NC	NC	80-120	0.0	20
Barium	0.013	2.1	2.0	2.0	2.0	102	99	80-120	3.3	20
Beryllium	0.0029	0.053	0.053	0.050	0.050	100	100	80-120	0.0	20
Boron	NA	NA	NA	1.0	1.0	NC	NC	80-120	0.0	20
Cadmium	0.17	0.22	0.22	0.050	0.050	106	105	80-120	0.1	20
Calcium	430	480	470	50	50	NC	NC	80-120	2.5	20
Chromium	NA	NA	NA	0.20	0.20	NC	NC	80-120	0.0	20
Cobalt	0.11	0.63	0.61	0.50	0.50	103	99	80-120	3.0	20
Copper	ND	0.25	0.24	0.25	0.25	100	95	80-120	5.7	20
Iron	340	340	330	1.0	1.0	NC	NC	80-120	2.9	20
Lead	NA	NA	NA	0.50	0.50	NC	NC	80-120	0.0	20
Lithium	NA	NA	NA	1.0	1.0	NC	NC	80-120	0.0	20
Magnesium	160	210	200	50	50	106	94	80-120	3.0	20
Manganese	76	77	75	0.50	0.50	NC	NC	80-120	3.1	20
Molybdenum	NA	NA	NA	0.50	0.50	NC	NC	80-120	0.0	20
Nickel	0.18	0.69	0.69	0.50	0.50	102	102	80-120	0.0	20
Potassium	ND	54	52	50	50	108	105	80-120	3.1	20
Selenium	NA	NA	NA	0.50	0.50	NC	NC	80-120	0.0	20
Silver	ND	0.046	0.040	0.050	0.050	93	79	80-120	15	20
Sodium	9.9	62	60	50	50	105	101	80-120	3.0	20
Thallium	NA	NA	NA	2.0	2.0	NC	NC	80-120	0.0	20
Tin	NA	NA	NA	2.0	2.0	NC	NC	80-120	0.0	20
Titanium	NA	NA	NA	1.0	1.0	NC	NC	80-120	0.0	20
Vanadium	ND	0.52	0.51	0.50	0.50	103	101	80-120	2.0	20
Zinc	240	240	240	0.50	0.50	NC	NC	80-120	2.4	20

NA = Not Applicable  
NC = Not Calculated, calculation not applicable.  
ND = Not Detected

Calculations are performed before rounding to avoid round-off errors in calculated results.

# Chain of Custody Record



QUA-4124-1

Client <b>RAS, INC.</b>		Project Manager <b>SUE McCOOL</b>		Date <b>7-23-96</b>	Chain Of Custody Number <b>75658</b>
Address <b>311 Rock Ave</b>		Telephone Number (Area Code)/Fax Number		Lab Number	Page <b>1</b> of <b>1</b>

City <b>GOLDEN</b>	State <b>CO</b>	Zip Code <b>80401</b>	Site Contact	Lab Contact <b>ADU-e</b>	Analysis (Attach list if more space is needed)	Special Instructions/ Conditions of Receipt
Project Name <b>FRENCH GULCH</b>			Carrier/Waybill Number			

Sample I.D. No. and Description (Containers for each sample may be combined on one line)	Date	Time	Matrix			Containers & Preservatives								6010 Pb	6011 Cd	6012 Fe	6013 Zn	6014 Cu	6015 Ni	6016 Mn	6017 Al	6018 Si	6019 Ti	6020 Total	
			Aqueous	Sed.	Soil	Unpres.	H2SO4	HNO3	HCl	NaOH	ZnAc	NaOH													
F60035 (MW-3)	7-22-96	EARLY	X					X						X	X	X	X	X	X	X	X	X	X	X	50360
F60036 (MW-9)	"		X					X						X	X	X	X	X	X	X	X	X	X	X	-01
F60037 (MW-14)	"		Y					X						X	X	X	X	X	X	X	X	X	X	X	-02
F60038 (MW-16)	"		Y					X						X	X	X	X	X	X	X	X	X	X	X	-03
F60039 (#3 REEF FILL)	"		Y					X						X	X	X	X	X	X	X	X	X	X	X	-04
F60040 (RF-3)	"		X					X						X	X	X	X	X	X	X	X	X	X	X	-05
F60041 (KDS)	"		Y					X						X	X	X	X	X	X	X	X	X	X	X	-06
F60042 (FC@CB)	"		Y					X						X	X	X	X	X	X	X	X	X	X	X	-07
F60043 (6C)	"		Y					X						X	X	X	X	X	X	X	X	X	X	X	-08
F60044 (F6-7)	"		Y					X						X	X	X	X	X	X	X	X	X	X	X	-09
F60045 (F6-8)	"		Y					X						X	X	X	X	X	X	X	X	X	X	X	-10
	"	LATE	X					X						X	X	X	X	X	X	X	X	X	X	X	-11
																									-12

Possible Hazard Identification		Sample Disposal		QC Requirements (Specify)	
<input checked="" type="checkbox"/> Non-Hazard <input type="checkbox"/> Flammable <input type="checkbox"/> Skin Irritant <input type="checkbox"/> Poison B <input type="checkbox"/> Unknown		<input type="checkbox"/> Return To Client <input type="checkbox"/> Disposal By Lab <input type="checkbox"/> Archive For _____ Months		(A fee may be assessed if samples are retained longer than 3 months)	
Turn Around Time Required					
<input type="checkbox"/> 24 Hours <input type="checkbox"/> 48 Hours <input type="checkbox"/> 7 Days <input checked="" type="checkbox"/> 14 Days <input type="checkbox"/> 21 Days <input type="checkbox"/> Other _____					
1. Relinquished By <b>Jace Williams</b>		Date <b>July 23</b>	Time <b>3:30</b>	1. Received By <b>Bonnie Major</b>	
2. Relinquished By		Date	Time	2. Received By	
3. Relinquished By		Date	Time	3. Received By	

Comments

DISTRIBUTION: WHITE - Stays with the Sample; CANARY - Returned to Client with Report; PINK - Field Copy



Quanterra Incorporated  
4955 Yarrow Street  
Arvada, Colorado 80002

303 421-6611 Telephone  
303 431-7171 Fax

March 27, 1997

Mr. Art Morrissey  
R.A.S., Inc.  
311 Rock Avenue  
Golden, CO 80401

Dear Mr. Morrissey:

Enclosed is the report for twenty-two aqueous samples received at Quanterra Environmental Services, Denver laboratory on March 14, 1997.

Included with the report is a quality control summary.

Please call if you have any questions.

Sincerely,

A handwritten signature in cursive script that reads "Susan H. McCool".

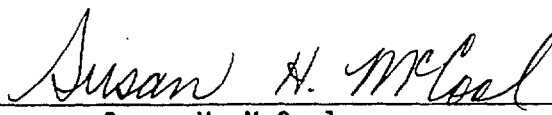
Susan H. McCool  
Project Manager

Enclosures

Quanterra #054191

ANALYTICAL RESULTS  
FOR  
R.A.S., Inc.  
FRENCH GULCH WATERSHEAD STUDY  
QUANTERRA ENVIRONMENTAL SERVICES  
DENVER NO. 054191  
MARCH 27, 1997

Reviewed by:

  
\_\_\_\_\_  
Susan H. McCool

# **Table Of Contents**

## ***Standard Deliverable***

### **Report Contents**

- Table of Contents
- Narrative
- LIMs Report Key
- Sample Description
- Test Requests
- Analytical Results
- QC Summary
- Chain-of-Custody
- Miscellaneous

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## Introduction

This report presents the analytical results as well as supporting information to aid in the evaluation and interpretation of the data and is arranged in the following order:

- o Sample Description Information
- o Analytical Test Requests
- o Analytical Results

All analyses at Quanterra are performed so that the maximum concentration of sample consistent with the method is analyzed. Dilutions are at times required to avoid saturation of the detector, to achieve linearity for a specific target compound, or to reduce matrix interferences. In this event, reporting limits are adjusted proportionately.

Samples 054191-0003, -0004, -0006, -0007, -0009, -0010, and -0022 were analyzed at dilutions by Method 6010 due to the elevated concentrations of zinc in the samples. The reporting limits were raised relative to the dilutions required.

## LIMs Report Key

Section	Description
Cover Letter	Signature page, report narrative as applicable.
Sample Description Information	Tabulated cross-reference between the Lab ID and Client ID, including matrix, date and time sampled, and the date received for all samples in the project.
Sample Analysis Results Sheets	Lists sample results, test components, reporting limits, dates prepared and analyzed, and any data qualifiers. Pages are organized by test.
QC LOT Assignment Report	Cross-reference between lab IDs and applicable QC batches (DCS, LCS, Blank, MS/SD, DU)
Duplicate Control Sample Report	Percent recovery and RPD results, with acceptance limits, for the laboratory duplicate control samples for each test are tabulated in this report. These are measures of accuracy and precision for each test. Acceptance limits are based upon laboratory historical data.
Laboratory Control Sample Report	Percent recovery results for a single Laboratory Control Sample (if applicable) are tabulated in this report, with the applicable acceptance limits for each test.
Matrix Spike/Matrix Spike Duplicate Report	Percent recovery and RPD results for matrix-specific QC samples and acceptance limits, where applicable. This report can be used to assess matrix effects on an analysis.
Single Control Sample Report	A tabulation of the surrogate recoveries for the blank for organic analyses.
Method Blank Report	A summary of the results of the analysis of the method blank for each test.

## List of Abbreviations and Terms

Abbreviation	Term	Abbreviation	Term
DCS	Duplicate Control Sample	MSD	Matrix Spike Duplicate
DU	Sample Duplicate	QC Run	Preparation Batch
EB	Equipment Blank	QC Category	LIMs QC Category
FB	Field Blank	QC Lot	DCS Batch
FD	Field Duplicate	ND	Not Detected at or above the reporting limit expressed
IDL	Instrument Detection Limit (Metals)	QC Matrix	Matrix of the laboratory control sample(s)
LCS	Laboratory Control Sample	RL	Reporting Limit
MB	Method Blank	QC	Quality Control
MDL	Method Detection Limit	SA	Sample
MS	Matrix Spike	SD	Spike Duplicate
RPD	Relative Percent Difference	TB	Trip Blank
ppm (part-per-million)	mg/L or mg/kg (usually)	ppb (part-per-billion)	ug/L or ug/kg (usually)
QUAL	Qualifier flag	DIL	Dilution Factor

### **Sample Description**

The Sample Description Information lists all of the samples received in this project together with the internal laboratory identification number assigned for each sample. Each project received at Quanterra's Denver laboratory is assigned a unique six digit number. Samples within the project are numbered sequentially. The laboratory identification number is a combination of the six digit project code and the sample sequence number.

Also given in the Sample Description Information is the Sample Type (matrix), Date of Sampling (if known) and Date of Receipt at the laboratory.

### **Analytical Test Requests**

The Analytical Test Requests lists the analyses that were performed on each sample. The Custom Test column indicates where tests have been modified to conform to the specific requirements of this project.



SAMPLE DESCRIPTION INFORMATION  
for  
R.A.S. Inc.

Lab ID	Client ID	Matrix	Sampled Date	Time	Received Date
054191-0001-SA	FG0055 (MW-14)	AQUEOUS	12 MAR 97	12:45	14 MAR 97
054191-0002-SA	FG0056 (MW-9)	AQUEOUS	12 MAR 97	13:30	14 MAR 97
054191-0003-SA	FG0057 (MSRW-3)	AQUEOUS	12 MAR 97	15:05	14 MAR 97
054191-0004-SA	FG0058 (MW-16)	AQUEOUS	12 MAR 97	15:30	14 MAR 97
054191-0005-SA	FG0059 (MW-2)	AQUEOUS	12 MAR 97	16:00	14 MAR 97
054191-0006-SA	FG0060 (MW-3)	AQUEOUS	12 MAR 97	16:30	14 MAR 97
054191-0007-SA	FG0061	AQUEOUS	12 MAR 97	16:30	14 MAR 97
054191-0008-SA	FG0062 (MW-11)	AQUEOUS	12 MAR 97	16:50	14 MAR 97
054191-0009-SA	FG0063 (MW-13)	AQUEOUS	12 MAR 97	17:35	14 MAR 97
054191-0010-SA	FG0064 (FG-6C)	AQUEOUS	13 MAR 97	13:45	14 MAR 97
054191-0011-SA	FG0065 (KDS)	AQUEOUS	13 MAR 97	09:15	14 MAR 97
054191-0012-SA	FG0066 (FCECB)	AQUEOUS	13 MAR 97	14:10	14 MAR 97
054191-0013-SA	FG0067 (FG-7)	AQUEOUS	13 MAR 97	11:05	14 MAR 97
054191-0014-SA	FG0068 (FG-8)	AQUEOUS	13 MAR 97	11:25	14 MAR 97
054191-0015-SA	FG0069 (MW-12)	AQUEOUS	13 MAR 97	10:00	14 MAR 97
054191-0016-SA	FG0070 (FG-1)	AQUEOUS	13 MAR 97	15:45	14 MAR 97
054191-0017-SA	FG0073 (FG-9)	AQUEOUS	13 MAR 97	10:35	14 MAR 97
054191-0018-SA	FG0074 (FG-15)	AQUEOUS	13 MAR 97	14:45	14 MAR 97
054191-0019-SA	FG0075 (1121)	AQUEOUS	13 MAR 97	12:25	14 MAR 97
054191-0020-SA	FG0076 (FG-6D)	AQUEOUS	13 MAR 97	13:10	14 MAR 97
054191-0021-SA	FG0077 (TS-4)	AQUEOUS	13 MAR 97	12:50	14 MAR 97
054191-0022-SA	FG0078 (SBRF-3)	AQUEOUS	13 MAR 97	16:40	14 MAR 97

ANALYTICAL TEST REQUESTS  
for  
R.A.S. Inc.

Page 1 of 1

Lab ID: 054191	Group Code	Analysis Description	Custom Test?
0001 - 0022	A	ICP Metals (Total) Prep - Total Metals, ICP	Y N

## **Analytical Results**

The analytical results for this project are presented in the following data tables. Each data table includes sample identification information, and when available and appropriate, dates sampled, received, authorized, prepared and analyzed. The authorization date is the date when the project was defined by the client such that laboratory work could begin.

Data sheets contain a listing of the parameters measured in each test, the analytical results and the Quanterra reporting limit. Reporting limits are adjusted to reflect dilution of the sample, when appropriate.

The results from the Standard Quanterra QA/QC Program, which generates data which are independent of matrix effects, are provided subsequently.

**Metals**  
**Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0055 (MW-14)  
Lab ID: 054191-0001-SA  
Matrix: AQUEOUS  
Authorized: 15 MAR 97

Sampled: 12 MAR 97  
Prepared: See Below

Received: 14 MAR 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.0059		1.0	0.0050	mg/L	6010	18 MAR 97	19 MAR 97
Iron	12.4		1.0	0.10	mg/L	6010	18 MAR 97	19 MAR 97
Zinc	1.9		1.0	0.020	mg/L	6010	18 MAR 97	19 MAR 97

Reported By: Doug Gomer

Approved By: Richard Persichitte

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0056 (MW-9)  
Lab ID: 054191-0002-SA  
Matrix: AQUEOUS  
Authorized: 15 MAR 97

Sampled: 12 MAR 97  
Prepared: See Below

Received: 14 MAR 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.0081		1.0	0.0050	mg/L	6010	18 MAR 97	19 MAR 97
Iron	0.36		1.0	0.10	mg/L	6010	18 MAR 97	19 MAR 97
Zinc	0.085		1.0	0.020	mg/L	6010	18 MAR 97	19 MAR 97

Reported By: Doug Gomer

Approved By: Richard Persichitte

**Metals**  
**Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0057 (MSRW-3)  
Lab ID: 054191-0003-SA  
Matrix: AQUEOUS  
Authorized: 15 MAR 97

Sampled: 12 MAR 97  
Prepared: See Below

Received: 14 MAR 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.19		2.0	0.010	mg/L	6010	18 MAR 97	19 MAR 97
Iron	155		2.0	0.20	mg/L	6010	18 MAR 97	19 MAR 97
Zinc	170		2.0	0.040	mg/L	6010	18 MAR 97	19 MAR 97

Reported By: Doug Gomer

Approved By: Richard Persichitte

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0058 (MW-16)  
Lab ID: 054191-0004-SA  
Matrix: AQUEOUS  
Authorized: 15 MAR 97

Sampled: 12 MAR 97  
Prepared: See Below

Received: 14 MAR 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.13		2.0	0.010	mg/L	6010	18 MAR 97	19 MAR 97
Iron	127		2.0	0.20	mg/L	6010	18 MAR 97	19 MAR 97
Zinc	140		2.0	0.040	mg/L	6010	18 MAR 97	19 MAR 97

Reported By: Doug Gomer

Approved By: Richard Persichitte

**Metals**  
**Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0059 (MW-2)  
Lab ID: 054191-0005-SA  
Matrix: AQUEOUS  
Authorized: 15 MAR 97

Sampled: 12 MAR 97  
Prepared: See Below

Received: 14 MAR 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.012		1.0	0.0050	mg/L	6010	18 MAR 97	19 MAR 97
Iron	113		1.0	0.10	mg/L	6010	18 MAR 97	19 MAR 97
Zinc	66.7		1.0	0.020	mg/L	6010	18 MAR 97	19 MAR 97

Reported By: Doug Gomer

Approved By: Richard Persichitte



Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0060 (MW-3)  
Lab ID: 054191-0006-SA  
Matrix: AQUEOUS  
Authorized: 15 MAR 97

Sampled: 12 MAR 97  
Prepared: See Below

Received: 14 MAR 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.16		2.0	0.010	mg/L	6010	18 MAR 97	19 MAR 97
Iron	221		2.0	0.20	mg/L	6010	18 MAR 97	19 MAR 97
Zinc	178		2.0	0.040	mg/L	6010	18 MAR 97	19 MAR 97

Reported By: Doug Gomer

Approved By: Richard Persichitte

**Metals**  
**Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0061  
Lab ID: 054191-0007-SA  
Matrix: AQUEOUS  
Authorized: 15 MAR 97

Sampled: 12 MAR 97  
Prepared: See Below

Received: 14 MAR 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.19		2.0	0.010	mg/L	6010	18 MAR 97	19 MAR 97
Iron	236		2.0	0.20	mg/L	6010	18 MAR 97	19 MAR 97
Zinc	189		2.0	0.040	mg/L	6010	18 MAR 97	19 MAR 97

Reported By: Doug Gomer

Approved By: Richard Persichitte

**Metals**  
**Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0062 (MW-11)  
Lab ID: 054191-0008-SA  
Matrix: AQUEOUS  
Authorized: 15 MAR 97

Sampled: 12 MAR 97  
Prepared: See Below

Received: 14 MAR 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.047		1.0	0.0050	mg/L	6010	18 MAR 97	19 MAR 97
Iron	ND		1.0	0.10	mg/L	6010	18 MAR 97	19 MAR 97
Zinc	3.9		1.0	0.020	mg/L	6010	18 MAR 97	19 MAR 97

ND = Not Detected

Reported By: Doug Gomer

Approved By: Richard Persichitte

**Metals**  
**Total Metals**

Client Name: R.A.S. Inc.  
 Client ID: FG0063 (MW-13)  
 Lab ID: 054191-0009-SA  
 Matrix: AQUEOUS  
 Authorized: 15 MAR 97

Sampled: 12 MAR 97  
 Prepared: See Below

Received: 14 MAR 97  
 Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	5.6		20	0.10	mg/L	6010	18 MAR 97	19 MAR 97
Iron	11.9		20	2.0	mg/L	6010	18 MAR 97	19 MAR 97
Zinc	1550		20	0.40	mg/L	6010	18 MAR 97	19 MAR 97

Reported By: Doug Gomer

Approved By: Richard Persichitte

**Metals**  
**Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0064 (FG-6C)  
Lab ID: 054191-0010-SA  
Matrix: AQUEOUS  
Authorized: 15 MAR 97

Sampled: 13 MAR 97  
Prepared: See Below

Received: 14 MAR 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.14		2.0	0.010	mg/L	6010	18 MAR 97	19 MAR 97
Iron	197		2.0	0.20	mg/L	6010	18 MAR 97	19 MAR 97
Zinc	164		2.0	0.040	mg/L	6010	18 MAR 97	19 MAR 97

Reported By: Doug Gomer

Approved By: Richard Persichitte

**Metals**  
**Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0065 (KDS)  
Lab ID: 054191-0011-SA  
Matrix: AQUEOUS  
Authorized: 15 MAR 97

Sampled: 13 MAR 97  
Prepared: See Below

Received: 14 MAR 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.0051		1.0	0.0050	mg/L	6010	18 MAR 97	19 MAR 97
Iron	1.5		1.0	0.10	mg/L	6010	18 MAR 97	19 MAR 97
Zinc	3.2		1.0	0.020	mg/L	6010	18 MAR 97	19 MAR 97

Reported By: Doug Gomer

Approved By: Richard Persichitte

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0066 (FCECB)  
Lab ID: 054191-0012-SA  
Matrix: AQUEOUS  
Authorized: 15 MAR 97

Sampled: 13 MAR 97  
Prepared: See Below

Received: 14 MAR 97  
Analyzed: See Below

Parameter	Result Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.0073	1.0	0.0050	mg/L	6010	18 MAR 97	19 MAR 97
Iron	ND	1.0	0.10	mg/L	6010	18 MAR 97	19 MAR 97
Zinc	0.021	1.0	0.020	mg/L	6010	18 MAR 97	19 MAR 97

ND = Not Detected

Reported By: Doug Gomer

Approved By: Richard Persichitte

**Metals**  
**Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0067 (FG-7)  
Lab ID: 054191-0013-SA  
Matrix: AQUEOUS  
Authorized: 15 MAR 97

Sampled: 13 MAR 97  
Prepared: See Below

Received: 14 MAR 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.026		1.0	0.0050	mg/L	6010	18 MAR 97	19 MAR 97
Iron	2.9		1.0	0.10	mg/L	6010	18 MAR 97	19 MAR 97
Zinc	15.9		1.0	0.020	mg/L	6010	18 MAR 97	19 MAR 97

Reported By: Doug Gomer

Approved By: Richard Persichitte



Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0068 (FG-8)  
Lab ID: 054191-0014-SA  
Matrix: AQUEOUS  
Authorized: 15 MAR 97

Sampled: 13 MAR 97  
Prepared: See Below

Received: 14 MAR 97  
Analyzed: See Below

Parameter	Result Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	ND	1.0	0.0050	mg/L	6010	18 MAR 97	19 MAR 97
Iron	ND	1.0	0.10	mg/L	6010	18 MAR 97	19 MAR 97
Zinc	0.55	1.0	0.020	mg/L	6010	18 MAR 97	19 MAR 97

ND = Not Detected

Reported By: Doug Gomer

Approved By: Richard Persichitte

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0069 (MW-12)  
Lab ID: 054191-0015-SA  
Matrix: AQUEOUS  
Authorized: 15 MAR 97

Sampled: 13 MAR 97  
Prepared: See Below

Received: 14 MAR 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.0052		1.0	0.0050	mg/L	6010	18 MAR 97	20 MAR 97
Iron	0.46		1.0	0.10	mg/L	6010	18 MAR 97	20 MAR 97
Zinc	0.14		1.0	0.020	mg/L	6010	18 MAR 97	20 MAR 97

Reported By: Patrick Carroll

Approved By: Richard Persichitte

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0070 (FG-1)  
Lab ID: 054191-0016-SA  
Matrix: AQUEOUS  
Authorized: 15 MAR 97

Sampled: 13 MAR 97  
Prepared: See Below

Received: 14 MAR 97  
Analyzed: See Below

Parameter	Result Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	ND	1.0	0.0050	mg/L	6010	18 MAR 97	20 MAR 97
Iron	0.24	1.0	0.10	mg/L	6010	18 MAR 97	20 MAR 97
Zinc	0.034	1.0	0.020	mg/L	6010	18 MAR 97	20 MAR 97

ND = Not Detected

Reported By: Patrick Carroll

Approved By: Richard Persichitte

**Metals**  
**Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0073 (FG-9)  
Lab ID: 054191-0017-SA  
Matrix: AQUEOUS  
Authorized: 15 MAR 97

Sampled: 13 MAR 97  
Prepared: See Below

Received: 14 MAR 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.011		1.0	0.0050	mg/L	6010	18 MAR 97	20 MAR 97
Iron	0.92		1.0	0.10	mg/L	6010	18 MAR 97	20 MAR 97
Zinc	4.8		1.0	0.020	mg/L	6010	18 MAR 97	20 MAR 97

Reported By: Patrick Carroll

Approved By: Richard Persichitte

**Metals  
Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0074 (FG-15)  
Lab ID: 054191-0018-SA  
Matrix: AQUEOUS  
Authorized: 15 MAR 97

Sampled: 13 MAR 97  
Prepared: See Below

Received: 14 MAR 97  
Analyzed: See Below

Parameter	Result Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	ND	1.0	0.0050	mg/L	6010	18 MAR 97	20 MAR 97
Iron	2.4	1.0	0.10	mg/L	6010	18 MAR 97	20 MAR 97
Zinc	1.2	1.0	0.020	mg/L	6010	18 MAR 97	20 MAR 97

ND = Not Detected

Reported By: Patrick Carroll

Approved By: Richard Persichitte

**Metals  
Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0075 (1121)  
Lab ID: 054191-0019-SA  
Matrix: AQUEOUS  
Authorized: 15 MAR 97

Sampled: 13 MAR 97  
Prepared: See Below

Received: 14 MAR 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.043		1.0	0.0050	mg/L	6010	18 MAR 97	20 MAR 97
Iron	36.9		1.0	0.10	mg/L	6010	18 MAR 97	20 MAR 97
Zinc	54.9		1.0	0.020	mg/L	6010	18 MAR 97	20 MAR 97

Reported By: Patrick Carroll

Approved By: Richard Persichitte

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0076 (FG-6D)  
Lab ID: 054191-0020-SA  
Matrix: AQUEOUS  
Authorized: 15 MAR 97

Sampled: 13 MAR 97  
Prepared: See Below

Received: 14 MAR 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.010		1.0	0.0050	mg/L	6010	18 MAR 97	20 MAR 97
Iron	17.1		1.0	0.10	mg/L	6010	18 MAR 97	20 MAR 97
Zinc	28.2		1.0	0.020	mg/L	6010	18 MAR 97	20 MAR 97

Reported By: Patrick Carroll

Approved By: Richard Persichitte

**Metals**  
**Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0077 (TS-4)  
Lab ID: 054191-0021-SA  
Matrix: AQUEOUS  
Authorized: 15 MAR 97

Sampled: 13 MAR 97  
Prepared: See Below

Received: 14 MAR 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	ND		1.0	0.0050	mg/L	6010	18 MAR 97	20 MAR 97
Iron	1.7		1.0	0.10	mg/L	6010	18 MAR 97	20 MAR 97
Zinc	0.57		1.0	0.020	mg/L	6010	18 MAR 97	20 MAR 97

ND = Not Detected

Reported By: Patrick Carroll

Approved By: Richard Persichitte



**Metals**  
**Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0078 (SBRF-3)  
Lab ID: 054191-0022-SA  
Matrix: AQUEOUS  
Authorized: 15 MAR 97

Sampled: 13 MAR 97  
Prepared: See Below

Received: 14 MAR 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	8.5		50	0.25	mg/L	6010	18 MAR 97	20 MAR 97
Iron	23100		50	5.0	mg/L	6010	18 MAR 97	20 MAR 97
Zinc	3400		50	1.0	mg/L	6010	18 MAR 97	20 MAR 97

Reported By: Patrick Carroll

Approved By: Richard Persichitte

**QC LOT ASSIGNMENT REPORT**  
Metals Analysis and Preparation

Laboratory Sample Number	QC Matrix	QC Category	QC Lot Number (DCS)	QC Run Number (SCS/BLANK)
054191-0001-SA	AQUEOUS	ICP-AT	18 MAR 97-N2	18 MAR 97-N2
054191-0002-SA	AQUEOUS	ICP-AT	18 MAR 97-N2	18 MAR 97-N2
054191-0003-SA	AQUEOUS	ICP-AT	18 MAR 97-N2	18 MAR 97-N2
054191-0004-SA	AQUEOUS	ICP-AT	18 MAR 97-N2	18 MAR 97-N2
054191-0005-SA	AQUEOUS	ICP-AT	18 MAR 97-N2	18 MAR 97-N2
054191-0006-SA	AQUEOUS	ICP-AT	18 MAR 97-N2	18 MAR 97-N2
054191-0007-SA	AQUEOUS	ICP-AT	18 MAR 97-N2	18 MAR 97-N2
054191-0008-SA	AQUEOUS	ICP-AT	18 MAR 97-N2	18 MAR 97-N2
054191-0009-SA	AQUEOUS	ICP-AT	18 MAR 97-N2	18 MAR 97-N2
054191-0010-SA	AQUEOUS	ICP-AT	18 MAR 97-N2	18 MAR 97-N2
054191-0011-SA	AQUEOUS	ICP-AT	18 MAR 97-N2	18 MAR 97-N2
054191-0012-SA	AQUEOUS	ICP-AT	18 MAR 97-N2	18 MAR 97-N2
054191-0013-SA	AQUEOUS	ICP-AT	18 MAR 97-N2	18 MAR 97-N2
054191-0014-SA	AQUEOUS	ICP-AT	18 MAR 97-N2	18 MAR 97-N2
054191-0015-SA	AQUEOUS	ICP-AT	18 MAR 97-N1	18 MAR 97-N1
054191-0016-SA	AQUEOUS	ICP-AT	18 MAR 97-N1	18 MAR 97-N1
054191-0017-SA	AQUEOUS	ICP-AT	18 MAR 97-N1	18 MAR 97-N1
054191-0018-SA	AQUEOUS	ICP-AT	18 MAR 97-N1	18 MAR 97-N1
054191-0019-SA	AQUEOUS	ICP-AT	18 MAR 97-N1	18 MAR 97-N1
054191-0020-SA	AQUEOUS	ICP-AT	18 MAR 97-N1	18 MAR 97-N1
054191-0021-SA	AQUEOUS	ICP-AT	18 MAR 97-N1	18 MAR 97-N1
054191-0022-SA	AQUEOUS	ICP-AT	18 MAR 97-N1	18 MAR 97-N1

LABORATORY CONTROL SAMPLE REPORT  
Metals Analysis and Preparation

Analyte	Concentration		Accuracy(%)	
	Spiked	Measured	LCS	Limits
Category: ICP-AT				
Matrix: AQUEOUS				
QC Lot: 18 MAR 97-N2				
Concentration Units: mg/L				
QC Run: 18 MAR 97-N2				
Aluminum	2.00	2.11	105	86-117
Antimony	0.500	0.527	105	81-119
Arsenic	2.00	2.00	100	81-110
Barium	2.00	2.06	103	86-114
Beryllium	0.0500	0.0441	88	83-117
Boron	1.00	1.48	148#	82-122
Cadmium	0.0500	0.0506	101	80-120
Calcium	50.0	51.1	102	88-112
Chromium	0.200	0.201	100	83-112
Cobalt	0.500	0.530	106	80-120
Copper	0.250	0.250	100	84-115
Iron	1.00	1.04	104	87-117
Lead	0.500	0.464	93	83-114
Lithium	1.00	0.866	87	80-120
Magnesium	50.0	51.0	102	84-114
Manganese	0.500	0.511	102	84-113
Molybdenum	1.00	1.00	100	80-120
Nickel	0.500	0.504	101	85-112
Potassium	50.0	49.1	98	82-111
Selenium	2.00	2.05	103	86-111
Silver	0.0500	0.0501	100	83-115
Sodium	50.0	51.5	103	86-115
Tin	2.00	2.10	105	86-114
Titanium	1.00	1.04	104	87-112
Vanadium	0.500	0.513	103	85-114
Zinc	0.500	0.505	101	82-113

# = Recovery outside QC Limits

Calculations are performed before rounding to avoid round-off errors in calculated results.

LABORATORY CONTROL SAMPLE REPORT  
 Metals Analysis and Preparation

(cont.)

Analyte	Concentration		Accuracy(%)	
	Spiked	Measured	LCS	Limits
Category: ICP-AT				
Matrix: AQUEOUS				
QC Lot: 18 MAR 97-N1				
Concentration Units: mg/L				
QC Run: 18 MAR 97-N1				
Aluminum	2.00	1.97	98	86-117
Antimony	0.500	0.538	108	81-119
Arsenic	2.00	2.00	100	81-110
Barium	2.00	2.00	100	86-114
Beryllium	0.0500	0.0433	87	83-117
Boron	1.00	0.935	93	82-122
Cadmium	0.0500	0.0460	92	80-120
Calcium	50.0	49.2	98	88-112
Chromium	0.200	0.200	100	83-112
Cobalt	0.500	0.512	102	80-120
Copper	0.250	0.233	93	84-115
Iron	1.00	1.00	100	87-117
Lead	0.500	0.515	103	83-114
Lithium	1.00	0.838	84	80-120
Magnesium	50.0	48.6	97	84-114
Manganese	0.500	0.493	99	84-113
Molybdenum	1.00	0.971	97	80-120
Nickel	0.500	0.500	100	85-112
Potassium	50.0	47.0	94	82-111
Selenium	2.00	1.93	97	86-111
Silver	0.0500	0.0454	91	83-115
Sodium	50.0	49.4	99	86-115
Tin	2.00	2.12	106	86-114
Titanium	1.00	0.986	99	87-112
Vanadium	0.500	0.490	98	85-114
Zinc	0.500	0.499	100	82-113

Calculations are performed before rounding to avoid round-off errors in calculated results.

METHOD BLANK REPORT  
Metals Analysis and Preparation

Analyte	Result	Units	Reporting Limit
Test: ICP-AT			
Matrix: AQUEOUS			
QC Lot: 18 MAR 97-N2 QC Run: 18 MAR 97-N2			
Cadmium	ND	mg/L	0.0050
Iron	ND	mg/L	0.10
Zinc	ND	mg/L	0.020

Test: ICP-AT			
Matrix: AQUEOUS			
QC Lot: 18 MAR 97-N1 QC Run: 18 MAR 97-N1			
Cadmium	ND	mg/L	0.0050
Iron	ND	mg/L	0.10
Zinc	ND	mg/L	0.020

MATRIX SPIKE/MATRIX SPIKE DUPLICATE QC REPORT  
Metals Analysis and Preparation  
Project: 054191

Category: ICP-AT ICP Metals / Total  
Matrix: AQUEOUS  
Sample: 054191-0014  
MS Run: 18 MAR 97-N2  
Units: mg/L

Analyte	Sample Result	Concentration		Amount Spiked		% Recovery		Recov. Accep.		RPD	
		MS Result	MSD Result	MS	MSD	MS	MSD	Limits	MS-MSD	Limits	Accept
Aluminum	ND	2.09	2.08	2.00	2.00	104	104	86-117	0.4	10	
Antimony	ND	0.543	0.539	0.500	0.500	109	108	81-119	0.7	10	
Arsenic	NA	NA	NA	2.00	2.00	NC	NC	81-110	NC	10	
Barium	0.019	2.08	2.03	2.00	2.00	103	101	86-114	2.2	10	
Beryllium	ND	0.0479	0.0474	0.0500	0.0500	96	95	83-117	1.1	10	
Boron	NA	NA	NA	1.00	1.00	NC	NC	82-122	NC	10	
Cadmium	ND	0.0560	0.0559	0.0500	0.0500	112	112	80-120	0.1	17	
Calcium	30.8	82.0	80.6	50.0	50.0	102	100	88-112	1.8	10	
Chromium	ND	0.205	0.201	0.200	0.200	103	101	83-112	2.0	10	
Cobalt	ND	0.529	0.521	0.500	0.500	106	104	80-120	1.4	10	
Copper	ND	0.253	0.251	0.250	0.250	101	100	84-115	1.1	10	
Iron	ND	1.08	1.05	1.00	1.00	108	105	87-117	2.7	10	
Lead	NA	NA	NA	0.500	0.500	NC	NC	83-114	NC	15	
Lithium	NA	NA	NA	1.00	1.00	NC	NC	80-120	NC	10	
Magnesium	3.7	55.5	54.2	50.0	50.0	104	101	84-114	2.4	10	
Manganese	0.018	0.531	0.518	0.500	0.500	103	100	84-113	2.5	10	
Molybdenum	NA	NA	NA	1.00	1.00	NC	NC	80-120	NC	10	
Nickel	ND	0.503	0.499	0.500	0.500	101	100	85-112	0.9	10	
Potassium	ND	50.1	49.1	50.0	50.0	100	98	82-111	2.0	10	
Selenium	NA	NA	NA	2.00	2.00	NC	NC	86-111	NC	10	
Silver	ND	0.0494	0.0484	0.0500	0.0500	99	97	83-115	2.0	10	
Sodium	ND	53.7	52.9	50.0	50.0	107	106	86-115	1.5	10	
Strontium	NA	NA	NA	1.00	1.00	NC	NC	80-120	NC	20	
Thallium	NA	NA	NA	2.00	2.00	NC	NC	80-120	NC	20	
Tin	NA	NA	NA	2.00	2.00	NC	NC	86-114	NC	10	
Titanium	NA	NA	NA	1.00	1.00	NC	NC	87-112	NC	10	
Vanadium	ND	0.514	0.508	0.500	0.500	103	102	85-114	1.2	10	
Zinc	0.55	1.04	1.02	0.500	0.500	99	96	82-113	1.4	10	

NA = Not Applicable

NC = Not Calculated, calculation not applicable.

ND = Not Detected

Calculations are performed before rounding to avoid round-off errors in calculated results.

ATRIX SPIKE/MATRIX SPIKE DUPLICATE QC REPORT  
Metals Analysis and Preparation  
Project: 054191 (cont.)

Category: ICP-AT ICP Metals / Total  
Matrix: AQUEOUS  
Sample: 054123-0002  
MS Run: 18 MAR 97-N1  
Units: mg/L

Analyte	Sample Result	Concentration		Amount Spiked		% Recovery		Recov.	RPD	
		MS Result	MSD Result	MS	MSD	MS	MSD	Accept. Limits	MS-MSD	Accept Limits
Aluminum	NA	NA	NA	2.00	2.00	NC	NC	86-117	NC	10
Antimony	NA	NA	NA	0.500	0.500	NC	NC	81-119	NC	10
Arsenic	NA	NA	NA	2.00	2.00	NC	NC	81-110	NC	10
Barium	0.042	2.06	2.05	2.00	2.00	101	100	86-114	0.6	10
Beryllium	NA	NA	NA	0.05000	0.0500	NC	NC	83-117	NC	10
Boron	NA	NA	NA	1.00	1.00	NC	NC	82-122	NC	10
Cadmium	ND	0.0458	0.0461	0.05000	0.0500	92	92	80-120	0.5	17
Calcium	NA	NA	NA	50.0	50.0	NC	NC	88-112	NC	10
Chromium	ND	0.199	0.202	0.200	0.200	100	101	83-112	1.4	10
Cobalt	ND	0.522	0.519	0.500	0.500	104	104	80-120	0.6	10
Copper	NA	NA	NA	0.250	0.250	NC	NC	84-115	NC	10
Iron	0.89	1.86	1.76	1.00	1.00	97	87	87-117	5.6	10
Lead	NA	NA	NA	0.500	0.500	NC	NC	83-114	NC	15
Lithium	NA	NA	NA	1.00	1.00	NC	NC	80-120	NC	10
Magnesium	NA	NA	NA	50.0	50.0	NC	NC	84-114	NC	10
Manganese	NA	NA	NA	0.500	0.500	NC	NC	84-113	NC	10
Molybdenum	NA	NA	NA	1.00	1.00	NC	NC	80-120	NC	10
Nickel	NA	NA	NA	0.500	0.500	NC	NC	85-112	NC	10
Potassium	NA	NA	NA	50.0	50.0	NC	NC	82-111	NC	10
Selenium	NA	NA	NA	2.00	2.00	NC	NC	86-111	NC	10
Silver	ND	0.0463	0.0492	0.05000	0.0500	93	98	83-115	6.1	10
Sodium	NA	NA	NA	50.0	50.0	NC	NC	86-115	NC	10
Strontium	NA	NA	NA	1.00	1.00	NC	NC	80-120	NC	20
Thallium	NA	NA	NA	2.00	2.00	NC	NC	80-120	NC	20
Tin	NA	NA	NA	2.00	2.00	NC	NC	86-114	NC	10
Titanium	NA	NA	NA	1.00	1.00	NC	NC	87-112	NC	10
Vanadium	NA	NA	NA	0.500	0.500	NC	NC	85-114	NC	10
Zinc	0.050	0.531	0.524	0.500	0.500	96	95	82-113	1.2	10

NA = Not Applicable

NC = Not Calculated, calculation not applicable.

ND = Not Detected

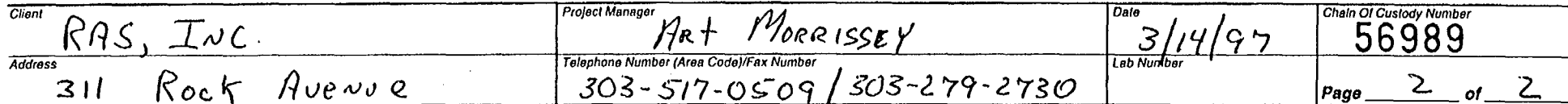
Calculations are performed before rounding to avoid round-off errors in calculated results.





QUA-4124-1

**Client**



City Golden	State CO	Zip Code 80401	Site Contact Art Morrissey	Lab Contact Sue McCool	Analysis (Attach list if more space is needed)
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[illegible]

Contract/Purchase Order/Quote No.	Matrix	Containers & Preservatives	Special Instructions	Conditions of Receipt
ATTN: See M. Cool				

[illegible]

<b>Possible Hazard Identification</b> <input checked="" type="checkbox"/> Non-Hazard <input type="checkbox"/> Flammable <input type="checkbox"/> Skin Irritant <input type="checkbox"/> Poison B <input type="checkbox"/> Unknown	<b>Sample Disposal</b> <input type="checkbox"/> Return To Client <input checked="" type="checkbox"/> Disposal By Lab <input type="checkbox"/> Archive For _____ Months <small>(A fee may be assessed if samples are retained longer than 3 months)</small>
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Turn Around Time Required: ☐ 24 Hours ☐ 48 Hours ☐ 7 Days ☐ 14 Days ☒ 21 Days ☐ Other \_\_\_\_\_

QC Requirements (Specify): stronger (see previous work)

1. Relinquished By		Date	Time	1. Received By		Date	Time
Pitt Morris		3/14/97	3:30 PM	J. Delcham		3/14/97	7:53 PM

2. Relinquished By	Date	Time	2. Received By	Date	Time

3. Relinquished By	Date	Time	3. Received By	Date	Time
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[illegible]



Quanterra Incorporated  
4955 Yarrow Street  
Arvada, Colorado 80002

303 421-6611 Telephone  
303 431-7171 Fax

June 24, 1997

Mr. Art Morrissey  
R.A.S., Inc.  
311 Rock Avenue  
Golden, CO 80401

Dear Mr. Morrissey:

Enclosed is the report for twenty-six aqueous samples received at Quanterra Environmental Services, Denver laboratory on May 31, 1997.

Included with the report is a quality control summary.

Please call if you have any questions.

Sincerely,

A handwritten signature in cursive script that reads "Susan H. McCool".

Susan H. McCool  
Project Manager

Enclosures

Quanterra #055475

# Invoice



Quanterra Environmental Services  
4955 Yarrow Street  
Arvada, CO 80002  
Tel: (303)421-6611  
Fax: (303)431-7171

Tel:  
Fax:

REMIT  
TO:

Quanterra, Incorporated  
P.O. Box 91501  
Chicago, IL 606931501

Number

0028121048

Quanterra Project Number

RMAL-055475

Terms

NET 30 DAYS

Customer Contact

Date

24 JUN 97

Customer Number

00374328

Bill To:

Art Morrissey  
R.A.S. Inc.  
311 Rock Avenue  
Golden, CO 80401

Art Morrissey  
R.A.S. Inc.  
311 Rock Avenue  
Golden, CO 80401

Line No.	Qty.	Matrix Code	Analysis Description	Unit Price	Extended Price
1	26	AQUEOUS	ANALYTICAL SERVICES Method 6010 - ICP Metals (Total)	59.00	1534.00
			Analytical Services Subtotal	1534.00	
			ADDITIONAL SERVICES		
			Additional Services Subtotal	0.00	
			French Gulch Watershed Study		

Customer Bill To: verbal per Bill Pedler

Customer Bill To: Susan McCool

Salesman: BOB WEIBEL

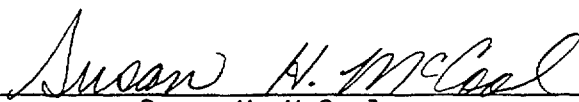
Sub Total  
Tax  
Total

1534.00

1534.00

ANALYTICAL RESULTS  
FOR  
R.A.S., Inc.  
FRENCH GULCH WATERSHEAD STUDY  
QUANTERRA ENVIRONMENTAL SERVICES  
DENVER NO. 055475  
JUNE 24, 1997

Reviewed by:

  
Susan H. McCool

# **Table Of Contents**

## ***Standard Deliverable***

### **Report Contents**

- Table of Contents
- Narrative
- LIMs Report Key
- Sample Description
- Test Requests
- Analytical Results
- QC Summary
- Chain-of-Custody
- Miscellaneous

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## Introduction

This report presents the analytical results as well as supporting information to aid in the evaluation and interpretation of the data and is arranged in the following order:

- o Sample Description Information
- o Analytical Test Requests
- o Analytical Results

All analyses at Quanterra are performed so that the maximum concentration of sample consistent with the method is analyzed. Dilutions are at times required to avoid saturation of the detector, to achieve linearity for a specific target compound, or to reduce matrix interferences. In this event, reporting limits are adjusted proportionately.

Samples 055475-0007, -0017, -0018, -0019, -0021, -0023, and -0026 were analyzed at dilutions by Method 6010 to bring the results for target analytes within the linear calibration range of the instrument. The reporting limits were raised relative to the dilutions required.

The spike recoveries were not calculable for total iron in the matrix specific batch QC (Lot: 06 JUN 97-L1) due to the elevated concentration of iron in the sample. All other associated QC is in control. Data are reported.

The spike recoveries were not calculable for total cadmium, iron, and zinc in the matrix specific batch QC (Lot: 11 JUN 97-H1) due to the elevated concentrations of these analytes in the sample. All other associated QC is in control. Data are reported.

The spike recoveries for total iron in the matrix specific batch QC (Lot: 16 JUN 97-H5) exceed the upper laboratory QC limits. The precision is in control for the matrix QC and the LCS is in control. Matrix interference is indicated.

## LIMs Report Key

Section	Description
Cover Letter	Signature page, report narrative as applicable.
Sample Description Information	Tabulated cross-reference between the Lab ID and Client ID, including matrix, date and time sampled, and the date received for all samples in the project.
Sample Analysis Results Sheets	Lists sample results, test components, reporting limits, dates prepared and analyzed, and any data qualifiers. Pages are organized by test.
QC LOT Assignment Report	Cross-reference between lab IDs and applicable QC batches (DCS, LCS, Blank, MS/SD, DU)
Duplicate Control Sample Report	Percent recovery and RPD results, with acceptance limits, for the laboratory duplicate control samples for each test are tabulated in this report. These are measures of accuracy and precision for each test. Acceptance limits are based upon laboratory historical data.
Laboratory Control Sample Report	Percent recovery results for a single Laboratory Control Sample (if applicable) are tabulated in this report, with the applicable acceptance limits for each test.
Matrix Spike/Matrix Spike Duplicate Report	Percent recovery and RPD results for matrix-specific QC samples and acceptance limits, where applicable. This report can be used to assess matrix effects on an analysis.
Single Control Sample Report	A tabulation of the surrogate recoveries for the blank for organic analyses.
Method Blank Report	A summary of the results of the analysis of the method blank for each test.

## List of Abbreviations and Terms

Abbreviation	Term	Abbreviation	Term
DCS	Duplicate Control Sample	MSD	Matrix Spike Duplicate
DU	Sample Duplicate	QC Run	Preparation Batch
EB	Equipment Blank	QC Category	LIMs QC Category
FB	Field Blank	QC Lot	DCS Batch
FD	Field Duplicate	ND	Not Detected at or above the reporting limit expressed
IDL	Instrument Detection Limit (Metals)	QC Matrix	Matrix of the laboratory control sample(s)
LCS	Laboratory Control Sample	RL	Reporting Limit
MB	Method Blank	QC	Quality Control
MDL	Method Detection Limit	SA	Sample
MS	Matrix Spike	SD	Spike Duplicate
RPD	Relative Percent Difference	TB	Trip Blank
ppm (part-per-million)	mg/L or mg/kg (usually)	ppb (part-per-billion)	ug/L or ug/kg (usually)
QUAL	Qualifier flag	DIL	Dilution Factor

## Sample Description

The Sample Description Information lists all of the samples received in this project together with the internal laboratory identification number assigned for each sample. Each project received at Quanterra's Denver laboratory is assigned a unique six digit number. Samples within the project are numbered sequentially. The laboratory identification number is a combination of the six digit project code and the sample sequence number.

Also given in the Sample Description Information is the Sample Type (matrix), Date of Sampling (if known) and Date of Receipt at the laboratory.

## Analytical Test Requests

The Analytical Test Requests lists the analyses that were performed on each sample. The Custom Test column indicates where tests have been modified to conform to the specific requirements of this project.



SAMPLE DESCRIPTION INFORMATION  
for  
R.A.S. Inc.

Lab ID	Client ID		Matrix	Sampled Date	Time	Received Date
055475-0001-SA	FG0082	(FG-9) STREAM	AQUEOUS	29 MAY 97	10:15	31 MAY 97
055475-0002-SA	FG0084	(FG-7) STREAM	AQUEOUS	29 MAY 97	10:45	31 MAY 97
055475-0003-SA	FG0085	(FG-8) STREAM	AQUEOUS	29 MAY 97	11:15	31 MAY 97
055475-0004-SA	FG0086	(1121 SEEP)	AQUEOUS	29 MAY 97	11:45	31 MAY 97
055475-0005-SA	FG0087	(USGS TS-4) STREAM	AQUEOUS	29 MAY 97	12:00	31 MAY 97
055475-0006-SA	FG0088	(FG-6D SEEP)	AQUEOUS	29 MAY 97	13:00	31 MAY 97
055475-0007-SA	FG0089	(FG-6C SEEP)	AQUEOUS	29 MAY 97	13:15	31 MAY 97
055475-0008-SA	FG0090	(FC@CB STREAM)	AQUEOUS	29 MAY 97	13:45	31 MAY 97
055475-0009-SA	FG0091	(USGS F6-15 INFLOW)	AQUEOUS	29 MAY 97	14:00	31 MAY 97
055475-0010-SA	FG0092		AQUEOUS	29 MAY 97	14:00	31 MAY 97
055475-0011-SA	FG0093	(KDS-SPRING)	AQUEOUS	29 MAY 97	14:45	31 MAY 97
055475-0012-SA	FG0096	(FG-1 STREAM)	AQUEOUS	29 MAY 97	15:30	31 MAY 97
055475-0013-SA	FG0097	(MW-12 GROUNDWATER)	AQUEOUS	30 MAY 97	09:40	31 MAY 97
055475-0014-SA	FG0098	(MW-14 GROUNDWATER)	AQUEOUS	30 MAY 97	10:10	31 MAY 97
055475-0015-SA	FG0099	(MW-9 GROUNDWATER)	AQUEOUS	30 MAY 97	10:35	31 MAY 97
055475-0016-SA	FG0100	(MW-11 GROUNDWATER)	AQUEOUS	30 MAY 97	11:05	31 MAY 97
055475-0017-SA	FG0101	(ORO SHAFT MINEWATER)	AQUEOUS	30 MAY 97	11:20	31 MAY 97
055475-0018-SA	FG0102	(WRO-1 GROUNDWATER)	AQUEOUS	30 MAY 97	12:40	31 MAY 97
055475-0019-SA	FG0103	(SBRF-3 GROUNDWATER)	AQUEOUS	30 MAY 97	13:10	31 MAY 97
055475-0020-SA	FG0104	(MW-16 GROUNDWATER)	AQUEOUS	30 MAY 97	13:25	31 MAY 97
055475-0021-SA	FG0105	(#3 MINESHAFT MINEWATE	AQUEOUS	30 MAY 97	13:45	31 MAY 97
055475-0022-SA	FG0106	(SEEP)	AQUEOUS	30 MAY 97	14:15	31 MAY 97
055475-0023-SA	FG0107	(MW-13 GROUNDWATER)	AQUEOUS	30 MAY 97	14:30	31 MAY 97
055475-0024-SA	FG0108	(WTL-02 GROUNDWATER)	AQUEOUS	30 MAY 97	15:10	31 MAY 97
055475-0025-SA	FG0109	(MW-2 GROUNDWATER)	AQUEOUS	30 MAY 97	15:20	31 MAY 97
055475-0026-SA	FG0110	(MW-3 GROUNDWATER)	AQUEOUS	30 MAY 97	15:50	31 MAY 97

ANALYTICAL TEST REQUESTS  
for  
R.A.S. Inc.

Page 1 of 1

Lab ID: 055475	Group Code	Analysis Description	Custom Test?
0001 - 0026	A	ICP Metals (Total)	Y
		Prep - Total Metals, ICP	N

## Analytical Results

The analytical results for this project are presented in the following data tables. Each data table includes sample identification information, and when available and appropriate, dates sampled, received, authorized, prepared and analyzed. The authorization date is the date when the project was defined by the client such that laboratory work could begin.

Data sheets contain a listing of the parameters measured in each test, the analytical results and the Quanterra reporting limit. Reporting limits are adjusted to reflect dilution of the sample, when appropriate.

The results from the Standard Quanterra QA/QC Program, which generates data which are independent of matrix effects, are provided subsequently.



Environmental  
Solutions

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0082 (FG-9) STREAM  
Lab ID: 055475-0001-SA  
Matrix: AQUEOUS  
Authorized: 03 JUN 97

Sampled: 29 MAY 97  
Prepared: See Below

Received: 31 MAY 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.0086		1.0	0.0050	mg/L	6010	06 JUN 97	09 JUN 97
Iron	0.34		1.0	0.10	mg/L	6010	06 JUN 97	09 JUN 97
Zinc	2.7		1.0	0.020	mg/L	6010	06 JUN 97	09 JUN 97

Reported By: Michelle Walker

Approved By: Lyle Ryman

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0084 (FG-7) STREAM  
Lab ID: 055475-0002-SA  
Matrix: AQUEOUS  
Authorized: 03 JUN 97

Sampled: 29 MAY 97  
Prepared: See Below

Received: 31 MAY 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.011		1.0	0.0050	mg/L	6010	06 JUN 97	09 JUN 97
Iron	0.53		1.0	0.10	mg/L	6010	06 JUN 97	09 JUN 97
Zinc	4.3		1.0	0.020	mg/L	6010	06 JUN 97	09 JUN 97

Reported By: Michelle Walker

Approved By: Lyle Ryman

Metals  
Total Metals

*Environmental  
Analysis*

Client Name: R.A.S. Inc.  
Client ID: FG0085 (FG-8) STREAM  
Lab ID: 055475-0003-SA  
Matrix: AQUEOUS  
Authorized: 03 JUN 97

Sampled: 29 MAY 97  
Prepared: See Below

Received: 31 MAY 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	ND		1.0	0.0050	mg/L	6010	06 JUN 97	09 JUN 97
Iron	0.19		1.0	0.10	mg/L	6010	06 JUN 97	09 JUN 97
Zinc	0.85		1.0	0.020	mg/L	6010	06 JUN 97	09 JUN 97

ND = Not Detected

Reported By: Michelle Walker

Approved By: Lyle Ryman



Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0086 (1121 SEEP)  
Lab ID: 055475-0004-SA  
Matrix: AQUEOUS  
Authorized: 03 JUN 97

Sampled: 29 MAY 97  
Prepared: See Below

Received: 31 MAY 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.060		1.0	0.0050	mg/L	6010	06 JUN 97	09 JUN 97
Iron	2.0		1.0	0.10	mg/L	6010	06 JUN 97	09 JUN 97
Zinc	27.8		1.0	0.020	mg/L	6010	06 JUN 97	09 JUN 97

Reported By: Michelle Walker

Approved By: Lyle Ryman

Metals  
Total Metals

Client Name: R.A.S. Inc.  
 Client ID: FG0087 (USGS TS-4) STREAM  
 Lab ID: 055475-0005-SA  
 Matrix: AQUEOUS  
 Authorized: 03 JUN 97

Sampled: 29 MAY 97  
 Prepared: See Below

Received: 31 MAY 97  
 Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.0064		1.0	0.0050	mg/L	6010	06 JUN 97	09 JUN 97
Iron	0.42		1.0	0.10	mg/L	6010	06 JUN 97	09 JUN 97
Zinc	1.6		1.0	0.020	mg/L	6010	06 JUN 97	09 JUN 97

Reported By: Michelle Walker

Approved By: Lyle Ryman



Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0088 (FG-6D SEEP)  
Lab ID: 055475-0006-SA  
Matrix: AQUEOUS  
Authorized: 03 JUN 97

Sampled: 29 MAY 97  
Prepared: See Below

Received: 31 MAY 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.0097		1.0	0.0050	mg/L	6010	06 JUN 97	09 JUN 97
Iron	4.4		1.0	0.10	mg/L	6010	06 JUN 97	09 JUN 97
Zinc	12.9		1.0	0.020	mg/L	6010	06 JUN 97	09 JUN 97

Reported By: Michelle Walker

Approved By: Lyle Ryman



Environmental  
Services

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0089 (FG-6C SEEP)  
Lab ID: 055475-0007-SA  
Matrix: AQUEOUS  
Authorized: 03 JUN 97

Sampled: 29 MAY 97  
Prepared: See Below

Received: 31 MAY 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.12		5.0	0.025	mg/L	6010	06 JUN 97	09 JUN 97
Iron	236		5.0	0.50	mg/L	6010	06 JUN 97	09 JUN 97
Zinc	234		5.0	0.10	mg/L	6010	06 JUN 97	09 JUN 97

Reported By: Michelle Walker

Approved By: Lyle Ryman



Environmental  
Services

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0090 (FC@CB STREAM)  
Lab ID: 055475-0008-SA  
Matrix: AQUEOUS  
Authorized: 03 JUN 97

Sampled: 29 MAY 97  
Prepared: See Below

Received: 31 MAY 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	ND		1.0	0.0050	mg/L	6010	06 JUN 97	09 JUN 97
Iron	0.62		1.0	0.10	mg/L	6010	06 JUN 97	09 JUN 97
Zinc	0.56		1.0	0.020	mg/L	6010	06 JUN 97	09 JUN 97

ND = Not Detected

Reported By: Michelle Walker

Approved By: Lyle Ryman



Environmental  
Services

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0091 (USGS F6-15 INFLOW)  
Lab ID: 055475-0009-SA  
Matrix: AQUEOUS  
Authorized: 03 JUN 97

Sampled: 29 MAY 97  
Prepared: See Below

Received: 31 MAY 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.16		1.0	0.0050	mg/L	6010	06 JUN 97	09 JUN 97
Iron	4.6		1.0	0.10	mg/L	6010	06 JUN 97	09 JUN 97
Zinc	32.1		1.0	0.020	mg/L	6010	06 JUN 97	09 JUN 97

Reported By: Michelle Walker

Approved By: Lyle Ryman

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0092  
Lab ID: 055475-0010-SA  
Matrix: AQUEOUS  
Authorized: 03 JUN 97

Sampled: 29 MAY 97  
Prepared: See Below

Received: 31 MAY 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.16		1.0	0.0050	mg/L	6010	06 JUN 97	09 JUN 97
Iron	4.3		1.0	0.10	mg/L	6010	06 JUN 97	09 JUN 97
Zinc	32.0		1.0	0.020	mg/L	6010	06 JUN 97	09 JUN 97

Reported By: Michelle Walker

Approved By: Lyle Ryman



Environmental  
Services

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0093 (KDS-SPRING)  
Lab ID: 055475-0011-SA  
Matrix: AQUEOUS  
Authorized: 03 JUN 97

Sampled: 29 MAY 97  
Prepared: See Below

Received: 31 MAY 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.022		1.0	0.0050	mg/L	6010	06 JUN 97	09 JUN 97
Iron	0.95		1.0	0.10	mg/L	6010	06 JUN 97	09 JUN 97
Zinc	10.5		1.0	0.020	mg/L	6010	06 JUN 97	09 JUN 97

Reported By: Michelle Walker

Approved By: Lyle Ryman



Environmental  
Services

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0096 (FG-1 STREAM)  
Lab ID: 055475-0012-SA  
Matrix: AQUEOUS  
Authorized: 03 JUN 97

Sampled: 29 MAY 97  
Prepared: See Below

Received: 31 MAY 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	ND		1.0	0.0050	mg/L	6010	06 JUN 97	09 JUN 97
Iron	ND		1.0	0.10	mg/L	6010	06 JUN 97	09 JUN 97
Zinc	0.057		1.0	0.020	mg/L	6010	06 JUN 97	09 JUN 97

ND = Not Detected

Reported By: Michelle Walker

Approved By: Lyle Ryman



Environmental  
Services

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0097 (MW-12 GROUNDWATER)  
Lab ID: 055475-0013-SA  
Matrix: AQUEOUS  
Authorized: 03 JUN 97

Sampled: 30 MAY 97  
Prepared: See Below

Received: 31 MAY 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	ND		1.0	0.0050	mg/L	6010	06 JUN 97	09 JUN 97
Iron	2.6		1.0	0.10	mg/L	6010	06 JUN 97	09 JUN 97
Zinc	0.40		1.0	0.020	mg/L	6010	06 JUN 97	09 JUN 97

ND = Not Detected

Reported By: Michelle Walker

Approved By: Lyle Ryman





Environmental  
Services

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0098 (MW-14 GROUNDWATER)  
Lab ID: 055475-0014-SA  
Matrix: AQUEOUS  
Authorized: 03 JUN 97

Sampled: 30 MAY 97  
Prepared: See Below

Received: 31 MAY 97  
Analyzed: See Below

Parameter	Result Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	ND	1.0	0.0050	mg/L	6010	11 JUN 97	16 JUN 97
Iron	19.4	1.0	0.10	mg/L	6010	11 JUN 97	16 JUN 97
Zinc	6.7	1.0	0.020	mg/L	6010	11 JUN 97	16 JUN 97

ND = Not Detected

Reported By: Michelle Walker

Approved By: Lyle Ryman

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0099 (MW-9 GROUNDWATER)  
Lab ID: 055475-0015-SA  
Matrix: AQUEOUS  
Authorized: 03 JUN 97

Sampled: 30 MAY 97  
Prepared: See Below

Received: 31 MAY 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	ND		1.0	0.0050	mg/L	6010	11 JUN 97	16 JUN 97
Iron	ND		1.0	0.10	mg/L	6010	11 JUN 97	16 JUN 97
Zinc	0.072		1.0	0.020	mg/L	6010	11 JUN 97	16 JUN 97

ND = Not Detected

Reported By: Michelle Walker

Approved By: Lyle Ryman

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0100 (MW-11 GROUNDWATER)  
Lab ID: 055475-0016-SA  
Matrix: AQUEOUS  
Authorized: 03 JUN 97

Sampled: 30 MAY 97  
Prepared: See Below

Received: 31 MAY 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.076		1.0	0.0050	mg/L	6010	11 JUN 97	16 JUN 97
Iron	ND		1.0	0.10	mg/L	6010	11 JUN 97	16 JUN 97
Zinc	8.5		1.0	0.020	mg/L	6010	11 JUN 97	16 JUN 97

ND = Not Detected

Reported By: Michelle Walker

Approved By: Lyle Ryman

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0101 (ORO SHAFT MINEWATER)  
Lab ID: 055475-0017-SA  
Matrix: AQUEOUS  
Authorized: 03 JUN 97

Sampled: 30 MAY 97  
Prepared: See Below

Received: 31 MAY 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.76		2.0	0.010	mg/L	6010	11 JUN 97	16 JUN 97
Iron	20.0		2.0	0.20	mg/L	6010	11 JUN 97	16 JUN 97
Zinc	136		2.0	0.040	mg/L	6010	11 JUN 97	16 JUN 97

Reported By: Michelle Walker

Approved By: Lyle Ryman



Environmental  
Services

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0102 (WRO-1 GROUNDWATER)  
Lab ID: 055475-0018-SA  
Matrix: AQUEOUS  
Authorized: 03 JUN 97

Sampled: 30 MAY 97  
Prepared: See Below

Received: 31 MAY 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	14.5		50	0.25	mg/L	6010	11 JUN 97	16 JUN 97
Iron	1260		50	5.0	mg/L	6010	11 JUN 97	16 JUN 97
Zinc	2750		50	1.0	mg/L	6010	11 JUN 97	16 JUN 97

Reported By: Michelle Walker

Approved By: Lyle Ryman

**Metals**  
**Total Metals**

Client Name: R.A.S. Inc.  
Client ID: FG0103 (SBRF-3 GROUNDWATER)  
Lab ID: 055475-0019-SA  
Matrix: AQUEOUS  
Authorized: 03 JUN 97

Sampled: 30 MAY 97  
Prepared: See Below

Received: 31 MAY 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	14.2		100	0.50	mg/L	6010	11 JUN 97	16 JUN 97
Iron	3240		100	10.0	mg/L	6010	11 JUN 97	16 JUN 97
Zinc	3180		100	2.0	mg/L	6010	11 JUN 97	16 JUN 97

Reported By: Michelle Walker

Approved By: Lyle Ryman



Environmental  
Services

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0104 (MW-16 GROUNDWATER)  
Lab ID: 055475-0020-SA  
Matrix: AQUEOUS  
Authorized: 03 JUN 97

Sampled: 30 MAY 97  
Prepared: See Below

Received: 31 MAY 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.057		1.0	0.0050	mg/L	6010	11 JUN 97	16 JUN 97
Iron	80.6		1.0	0.10	mg/L	6010	11 JUN 97	16 JUN 97
Zinc	87.6		1.0	0.020	mg/L	6010	11 JUN 97	16 JUN 97

Reported By: Michelle Walker

Approved By: Lyle Ryman



Environmental  
Services

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0105 (#3 MINESHAFT MINEWATER)  
Lab ID: 055475-0021-SA  
Matrix: AQUEOUS  
Authorized: 03 JUN 97  
Sampled: 30 MAY 97  
Prepared: See Below  
Received: 31 MAY 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.41		2.0	0.010	mg/L	6010	11 JUN 97	16 JUN 97
Iron	148		2.0	0.20	mg/L	6010	11 JUN 97	16 JUN 97
Zinc	192		2.0	0.040	mg/L	6010	11 JUN 97	16 JUN 97

Reported By: Michelle Walker

Approved By: Lyle Ryman



Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0106 (SEEP)  
Lab ID: 055475-0022-SA  
Matrix: AQUEOUS  
Authorized: 03 JUN 97

Sampled: 30 MAY 97  
Prepared: See Below

Received: 31 MAY 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.079		1.0	0.0050	mg/L	6010	11 JUN 97	16 JUN 97
Iron	0.75		1.0	0.10	mg/L	6010	11 JUN 97	16 JUN 97
Zinc	20.8		1.0	0.020	mg/L	6010	11 JUN 97	16 JUN 97

Reported By: Michelle Walker

Approved By: Lyle Ryman

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0107 (MW-13 GROUNDWATER)  
Lab ID: 055475-0023-SA  
Matrix: AQUEOUS  
Authorized: 03 JUN 97

Sampled: 30 MAY 97  
Prepared: See Below

Received: 31 MAY 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	4.8		20	0.10	mg/L	6010	16 JUN 97	17 JUN 97
Iron	14.6		20	2.0	mg/L	6010	16 JUN 97	17 JUN 97
Zinc	1280		20	0.40	mg/L	6010	16 JUN 97	17 JUN 97

Reported By: Michelle Walker

Approved By: Lyle Ryman



Environmental  
Services

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0108 (WTL-02 GROUNDWATER)  
Lab ID: 055475-0024-SA  
Matrix: AQUEOUS  
Authorized: 03 JUN 97  
Sampled: 30 MAY 97  
Prepared: See Below  
Received: 31 MAY 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.011		1.0	0.0050	mg/L	6010	16 JUN 97	17 JUN 97
Iron	86.7		1.0	0.10	mg/L	6010	16 JUN 97	17 JUN 97
Zinc	86.8		1.0	0.020	mg/L	6010	16 JUN 97	17 JUN 97

Reported By: Michelle Walker

Approved By: Lyle Ryman

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0109 (MW-2 GROUNDWATER)  
Lab ID: 055475-0025-SA  
Matrix: AQUEOUS  
Authorized: 03 JUN 97

Sampled: 30 MAY 97  
Prepared: See Below

Received: 31 MAY 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	ND		1.0	0.0050	mg/L	6010	16 JUN 97	17 JUN 97
Iron	168		1.0	0.10	mg/L	6010	16 JUN 97	17 JUN 97
Zinc	14.9		1.0	0.020	mg/L	6010	16 JUN 97	17 JUN 97

ND = Not Detected

Reported By: Michelle Walker

Approved By: Lyle Ryman

Metals  
Total Metals

Client Name: R.A.S. Inc.  
Client ID: FG0110 (MW-3 GROUNDWATER)  
Lab ID: 055475-0026-SA  
Matrix: AQUEOUS  
Authorized: 03 JUN 97

Sampled: 30 MAY 97  
Prepared: See Below

Received: 31 MAY 97  
Analyzed: See Below

Parameter	Result	Qual	Dil	RL	Units	Test Method	Prepared Date	Analyzed Date
Cadmium	0.26		5.0	0.025	mg/L	6010	16 JUN 97	17 JUN 97
Iron	351		5.0	0.50	mg/L	6010	16 JUN 97	17 JUN 97
Zinc	325		5.0	0.10	mg/L	6010	16 JUN 97	17 JUN 97

Reported By: Michelle Walker

Approved By: Lyle Ryman

QC LOT ASSIGNMENT REPORT  
Metals Analysis and Preparation

Laboratory Sample Number	QC Matrix	QC Category	QC Lot Number (DCS)	QC Run Number (SCS/BLANK)
055475-0001-SA	AQUEOUS	ICP-AT	06 JUN 97-L1	06 JUN 97-L1
055475-0002-SA	AQUEOUS	ICP-AT	06 JUN 97-L1	06 JUN 97-L1
055475-0003-SA	AQUEOUS	ICP-AT	06 JUN 97-L1	06 JUN 97-L1
055475-0004-SA	AQUEOUS	ICP-AT	06 JUN 97-L1	06 JUN 97-L1
055475-0005-SA	AQUEOUS	ICP-AT	06 JUN 97-L1	06 JUN 97-L1
055475-0006-SA	AQUEOUS	ICP-AT	06 JUN 97-L1	06 JUN 97-L1
055475-0007-SA	AQUEOUS	ICP-AT	06 JUN 97-L1	06 JUN 97-L1
055475-0008-SA	AQUEOUS	ICP-AT	06 JUN 97-L1	06 JUN 97-L1
055475-0009-SA	AQUEOUS	ICP-AT	06 JUN 97-L1	06 JUN 97-L1
055475-0010-SA	AQUEOUS	ICP-AT	06 JUN 97-L1	06 JUN 97-L1
055475-0011-SA	AQUEOUS	ICP-AT	06 JUN 97-L1	06 JUN 97-L1
055475-0012-SA	AQUEOUS	ICP-AT	06 JUN 97-L1	06 JUN 97-L1
055475-0013-SA	AQUEOUS	ICP-AT	06 JUN 97-L1	06 JUN 97-L1
055475-0014-SA	AQUEOUS	ICP-AT	11 JUN 97-H1	11 JUN 97-H1
055475-0015-SA	AQUEOUS	ICP-AT	11 JUN 97-H1	11 JUN 97-H1
055475-0016-SA	AQUEOUS	ICP-AT	11 JUN 97-H1	11 JUN 97-H1
055475-0017-SA	AQUEOUS	ICP-AT	11 JUN 97-H1	11 JUN 97-H1
055475-0018-SA	AQUEOUS	ICP-AT	11 JUN 97-H1	11 JUN 97-H1
055475-0019-SA	AQUEOUS	ICP-AT	11 JUN 97-H1	11 JUN 97-H1
055475-0020-SA	AQUEOUS	ICP-AT	11 JUN 97-H1	11 JUN 97-H1
055475-0021-SA	AQUEOUS	ICP-AT	11 JUN 97-H1	11 JUN 97-H1
055475-0022-SA	AQUEOUS	ICP-AT	11 JUN 97-H1	11 JUN 97-H1
055475-0023-SA	AQUEOUS	ICP-AT	16 JUN 97-H5	16 JUN 97-H5
055475-0024-SA	AQUEOUS	ICP-AT	16 JUN 97-H5	16 JUN 97-H5
055475-0025-SA	AQUEOUS	ICP-AT	16 JUN 97-H5	16 JUN 97-H5
055475-0026-SA	AQUEOUS	ICP-AT	16 JUN 97-H5	16 JUN 97-H5

LABORATORY CONTROL SAMPLE REPORT  
Metals Analysis and Preparation

Analyte	Concentration		Accuracy (%)	
	Spiked	Measured	LCS	Limits
Category: ICP-AT				
Matrix: AQUEOUS				
QC Lot: 06 JUN 97-L1				
Concentration Units: mg/L				
QC Run: 06 JUN 97-L1				
Aluminum	2.00	1.82	91	86-117
Antimony	0.500	0.480	96	81-119
Arsenic	2.00	1.78	89	81-110
Barium	2.00	1.78	89	86-114
Beryllium	0.0500	0.0454	91	83-117
Boron	1.00	0.907	91	82-122
Cadmium	0.0500	0.0504	101	80-120
Calcium	50.0	46.3	93	88-112
Chromium	0.200	0.182	91	83-112
Cobalt	0.500	0.464	93	80-120
Copper	0.250	0.222	89	84-115
Iron	1.00	0.932	93	87-117
Lead	0.500	0.449	90	83-114
Lithium	1.00	0.877	88	80-120
Magnesium	50.0	46.8	94	84-114
Manganese	0.500	0.447	89	84-113
Molybdenum	1.00	0.916	92	80-120
Nickel	0.500	0.473	95	85-112
Potassium	50.0	47.2	94	82-111
Selenium	2.00	1.87	94	86-111
Silver	0.0500	0.0438	88	83-115
Sodium	50.0	44.7	89	86-115
Tin	2.00	1.93	96	86-114
Titanium	1.00	0.884	88	87-112
Vanadium	0.500	0.450	90	85-114
Zinc	0.500	0.457	91	82-113

Calculations are performed before rounding to avoid round-off errors in calculated results

LABORATORY CONTROL SAMPLE REPORT  
 Metals Analysis and Preparation

(cont.)

Analyte	Concentration		Accuracy (%)	
	Spiked	Measured	LCS	Limits
Category: ICP-AT				
Matrix: AQUEOUS				
QC Lot: 11 JUN 97-H1				
Concentration Units: mg/L				
QC Run: 11 JUN 97-H1				
Aluminum	2.00	2.16	108	86-117
Antimony	0.500	0.550	110	81-119
Arsenic	2.00	2.09	104	81-110
Barium	2.00	2.11	106	86-114
Beryllium	0.0500	0.0490	98	83-117
Boron	1.00	1.07	107	82-122
Cadmium	0.0500	0.0448	90	80-120
Calcium	50.0	52.5	105	88-112
Chromium	0.200	0.207	104	83-112
Cobalt	0.500	0.532	106	80-120
Copper	0.250	0.249	100	84-115
Iron	1.00	1.06	106	87-117
Lead	0.500	0.524	105	83-114
Lithium	1.00	0.959	96	80-120
Magnesium	50.0	54.4	109	84-114
Manganese	0.500	0.520	104	84-113
Molybdenum	1.00	1.04	104	80-120
Nickel	0.500	0.527	105	85-112
Potassium	50.0	50.2	100	82-111
Selenium	2.00	2.07	103	86-111
Silver	0.0500	0.0521	104	83-115
Sodium	50.0	51.5	103	86-115
Tin	2.00	2.17	109	86-114
Titanium	1.00	1.05	105	87-112
Vanadium	0.500	0.522	104	85-114
Zinc	0.500	0.528	106	82-113

Calculations are performed before rounding to avoid round-off errors in calculated results





Environmental  
Services

LABORATORY CONTROL SAMPLE REPORT  
Metals Analysis and Preparation

(cont.)

Analyte	Concentration		Accuracy(%)	
	Spiked	Measured	LCS	Limits
Category: ICP-AT				
Matrix: AQUEOUS				
QC Lot: 16 JUN 97-H5				
Concentration Units: mg/L				
QC Run: 16 JUN 97-H5				
Aluminum	2.00	NA	NC	86-117
Antimony	0.500	NA	NC	81-119
Arsenic	2.00	NA	NC	81-110
Barium	2.00	2.09	105	86-114
Beryllium	0.0500	NA	NC	83-117
Boron	1.00	NA	NC	82-122
Cadmium	0.0500	0.0487	97	80-120
Calcium	50.0	NA	NC	88-112
Chromium	0.200	0.205	103	83-112
Cobalt	0.500	NA	NC	80-120
Copper	0.250	NA	NC	84-115
Iron	1.00	1.02	102	87-117
Lead	0.500	NA	NC	83-114
Lithium	1.00	NA	NC	80-120
Magnesium	50.0	NA	NC	84-114
Manganese	0.500	NA	NC	84-113
Molybdenum	1.00	NA	NC	80-120
Nickel	0.500	NA	NC	85-112
Potassium	50.0	NA	NC	82-111
Selenium	2.00	NA	NC	86-111
Silver	0.0500	0.0522	104	83-115
Sodium	50.0	NA	NC	86-115
Tin	2.00	NA	NC	86-114
Titanium	1.00	NA	NC	87-112
Vanadium	0.500	NA	NC	85-114
Zinc	0.500	0.503	101	82-113

NA = Not Applicable

NC = Not Calculated, calculation not applicable.

Calculations are performed before rounding to avoid round-off errors in calculated results.

METHOD BLANK REPORT  
Metals Analysis and Preparation

Analyte	Result	Units	Reporting Limit
Test: ICP-AT			
Matrix: AQUEOUS			
QC Lot: 06 JUN 97-L1 QC Run: 06 JUN 97-L1			
Cadmium	ND	mg/L	0.0050
Iron	ND	mg/L	0.10
Zinc	ND	mg/L	0.020
Test: ICP-AT			
Matrix: AQUEOUS			
QC Lot: 11 JUN 97-H1 QC Run: 11 JUN 97-H1			
Cadmium	ND	mg/L	0.0050
Iron	ND	mg/L	0.10
Zinc	ND	mg/L	0.020
Test: ICP-AT			
Matrix: AQUEOUS			
QC Lot: 16 JUN 97-H5 QC Run: 16 JUN 97-H5			
Cadmium	ND	mg/L	0.0050
Iron	ND	mg/L	0.10
Zinc	ND	mg/L	0.020

TRIX SPIKE/MATRIX SPIKE DUPLICATE QC REPORT  
Metals Analysis and Preparation  
Project: 055475

Category: ICP-AT ICP Metals / Total  
Matrix: AQUEOUS  
Sample: 055379-0003  
MS Run: 06 JUN 97-L1  
Units: mg/L

Concentration

Analyte	Sample Result	MS Result	MSD Result	Amount		% Recovery	Recov. Accep.	RPD	MS-MSD	RPD Accept
				Spiked MS	MSD					
Aluminum	NA	NA	NA	2.00	2.00	NC	NC	86-117	NC	10
Antimony	NA	NA	NA	0.500	0.500	NC	NC	81-119	NC	10
Arsenic	NA	NA	NA	2.00	2.00	NC	NC	81-110	NC	10
Barium	NA	NA	NA	2.00	2.00	NC	NC	86-114	NC	10
Beryllium	NA	NA	NA	0.05000	0.0500	NC	NC	83-117	NC	10
Boron	NA	NA	NA	1.00	1.00	NC	NC	82-122	NC	10
Cadmium	ND	0.0514	0.0502	0.05000	0.0500	103	100	80-120	2.4	17
Calcium	NA	NA	NA	50.0	50.0	NC	NC	88-112	NC	10
Chromium	NA	NA	NA	0.200	0.200	NC	NC	83-112	NC	10
Cobalt	NA	NA	NA	0.500	0.500	NC	NC	80-120	NC	10
Copper	NA	NA	NA	0.250	0.250	NC	NC	84-115	NC	10
Iron	12.7	13.5	13.5	1.00	1.00	NC	NC	87-117	NC	10
Lead	ND	0.454	0.468	0.500	0.500	91	94	83-114	3.0	15
Lithium	NA	NA	NA	1.00	1.00	NC	NC	80-120	NC	10
Magnesium	NA	NA	NA	50.0	50.0	NC	NC	84-114	NC	10
Manganese	NA	NA	NA	0.500	0.500	NC	NC	84-113	NC	10
Molybdenum	NA	NA	NA	1.00	1.00	NC	NC	80-120	NC	10
Nickel	NA	NA	NA	0.500	0.500	NC	NC	85-112	NC	10
Potassium	NA	NA	NA	50.0	50.0	NC	NC	82-111	NC	10
Selenium	NA	NA	NA	2.00	2.00	NC	NC	86-111	NC	10
Silver	NA	NA	NA	0.05000	0.0500	NC	NC	83-115	NC	10
Sodium	NA	NA	NA	50.0	50.0	NC	NC	86-115	NC	10
Strontium	NA	NA	NA	1.00	1.00	NC	NC	80-120	NC	20
Thallium	NA	NA	NA	2.00	2.00	NC	NC	80-120	NC	20
Tin	NA	NA	NA	2.00	2.00	NC	NC	86-114	NC	10
Titanium	NA	NA	NA	1.00	1.00	NC	NC	87-112	NC	10
Vanadium	NA	NA	NA	0.500	0.500	NC	NC	85-114	NC	10
Zinc	0.020	0.467	0.472	0.500	0.500	89	90	82-113	1.0	10

NA = Not Applicable  
NC = Not Calculated, calculation not applicable.  
ND = Not Detected

Calculations are performed before rounding to avoid round-off errors in calculated results.

TRIX SPIKE/MATRIX SPIKE DUPLICATE QC REPORT  
 cals Analysis and Preparation  
 roject: 055475 (cont.)

Category: ICP-AT ICP Metals / Total  
 Matrix: AQUEOUS  
 Sample: 055475-0021  
 Run: 11 JUN 97-H1  
 Units: mg/L

Analyte	Concentration			Amount		% Recov.		RPD		
	Sample Result	MS Result	MSD Result	Spiked		Recovery		Accep. RPD Limits	MS-MSD Limits	
				MS	MSD	MS	MSD			
Aluminum	2.9	5.20	5.05	2.00	2.00	112	105	86-117	2.8	10
Antimony	NA	NA	NA	0.500	0.500	NC	NC	81-119	NC	10
Arsenic	NA	NA	NA	2.00	2.00	NC	NC	81-110	NC	10
Barium	NA	NA	NA	2.00	2.00	NC	NC	86-114	NC	10
Beryllium	NA	NA	NA	0.05000	0.0500	NC	NC	83-117	NC	10
Boron	NA	NA	NA	1.00	1.00	NC	NC	82-122	NC	10
Cadmium	0.41	0.467	0.446	0.05000	0.0500	NC	NC	80-120	NC	17
Calcium	338	390	380	50.0	50.0	NC	NC	88-112	NC	10
Chromium	NA	NA	NA	0.200	0.200	NC	NC	83-112	NC	10
Cobalt	NA	NA	NA	0.500	0.500	NC	NC	80-120	NC	10
Copper	NA	NA	NA	0.250	0.250	NC	NC	84-115	NC	10
Iron	148	148	145	1.00	1.00	NC	NC	87-117	NC	10
Lead	NA	NA	NA	0.500	0.500	NC	NC	83-114	NC	15
Lithium	NA	NA	NA	1.00	1.00	NC	NC	80-120	NC	10
Magnesium	115	173	169	50.0	50.0	116	108	84-114	2.3	10
Manganese	43.1	43.3	42.3	0.500	0.500	NC	NC	84-113	NC	10
Molybdenum	NA	NA	NA	1.00	1.00	NC	NC	80-120	NC	10
Nickel	0.13	0.683	0.660	0.500	0.500	111	107	85-112	3.4	10
Potassium	2.8	54.6	53.3	50.0	50.0	104	101	82-111	2.5	10
Selenium	NA	NA	NA	2.00	2.00	NC	NC	86-111	NC	10
Silver	0.00021	0.0561	0.0573	0.05000	0.0500	112	114	83-115	2.1	10
Sodium	27.8	82.3	78.8	50.0	50.0	109	102	86-115	4.4	10
Strontium	NA	NA	NA	1.00	1.00	NC	NC	80-120	NC	20
Thallium	NA	NA	NA	2.00	2.00	NC	NC	80-120	NC	20
Tin	NA	NA	NA	2.00	2.00	NC	NC	86-114	NC	10
Titanium	NA	NA	NA	1.00	1.00	NC	NC	87-112	NC	10
Vanadium	NA	NA	NA	0.500	0.500	NC	NC	85-114	NC	10
Zinc	192	190	186	0.500	0.500	NC	NC	82-113	NC	10

NA = Not Applicable

NC = Not Calculated, calculation not applicable.

Calculations are performed before rounding to avoid round-off errors in calculated results.



Environmental  
Services

TRIX SPIKE/MATRIX SPIKE DUPLICATE QC REPORT  
Metals Analysis and Preparation  
Project: 055475 (cont.)

Category: ICP-AT ICP Metals / Total  
Matrix: AQUEOUS  
Sample: 055426-0005  
MS Run: 16 JUN 97-H5  
Units: mg/L

Concentration

Analyte	Sample Result	MS Result	MSD Result	Amount		% Recovery	Recov. Accep.	RPD Limits	RPD Accept Limits	
				Spiked MS	MSD MSD					
Aluminum	ND	5.14	5.22	2.00	2.00	257	261	86-117	1.5	10
Antimony	NA	NA	NA	0.500	0.500	NC	NC	81-119	NC	10
Arsenic	NA	NA	NA	2.00	2.00	NC	NC	81-110	NC	10
Barium	0.025	2.19	2.15	2.00	2.00	108	106	86-114	1.7	10
Beryllium	ND	0.0498	0.0490	0.05000	0.0500	100	98	83-117	1.6	10
Boron	NA	NA	NA	1.00	1.00	NC	NC	82-122	NC	10
Cadmium	ND	0.0478	0.0478	0.05000	0.0500	96	96	80-120	0.0	17
Calcium	64.3	132	129	50.0	50.0	135	130	88-112	2.1	10
Chromium	ND	0.210	0.209	0.200	0.200	105	104	83-112	0.6	10
Cobalt	NA	NA	NA	0.500	0.500	NC	NC	80-120	NC	10
Copper	NA	NA	NA	0.250	0.250	NC	NC	84-115	NC	10
Iron	ND	6.49	6.43	1.00	1.00	649	643	87-117	0.8	10
Lead	NA	NA	NA	0.500	0.500	NC	NC	83-114	NC	15
Mercury	NA	NA	NA	1.00	1.00	NC	NC	80-120	NC	10
Magnesium	17.4	75.9	74.4	50.0	50.0	117	114	84-114	2.0	10
Manganese	ND	1.02	1.00	0.500	0.500	204	200	84-113	1.8	10
Molybdenum	NA	NA	NA	1.00	1.00	NC	NC	80-120	NC	10
Nickel	ND	0.524	0.525	0.500	0.500	105	105	85-112	0.1	10
Potassium	ND	59.9	58.1	50.0	50.0	120	116	82-111	3.0	10
Selenium	NA	NA	NA	2.00	2.00	NC	NC	86-111	NC	10
Silver	ND	0.0308	0.0505	0.05000	0.0500	62	101	83-115	49	10
Sodium	227	286	278	50.0	50.0	NC	NC	86-115	NC	10
Strontium	NA	NA	NA	1.00	1.00	NC	NC	80-120	NC	20
Thallium	NA	NA	NA	2.00	2.00	NC	NC	80-120	NC	20
Tin	NA	NA	NA	2.00	2.00	NC	NC	86-114	NC	10
Titanium	NA	NA	NA	1.00	1.00	NC	NC	87-112	NC	10
Vanadium	NA	NA	NA	0.500	0.500	NC	NC	85-114	NC	10
Zinc	ND	0.557	0.548	0.500	0.500	111	110	82-113	1.6	10

NA = Not Applicable

NC = Not Calculated, calculation not applicable.

ND = Not Detected

Calculations are performed before rounding to avoid round-off errors in calculated results.

# Chain of Custody Record



QUA-4124

Client <b>RAS, Inc.</b>			Project Manager <b>ART MORRISSEY</b>			Date <b>5/31/97</b>		Chain Of Custody Number <b>27211</b>	
Address <b>311 Rock Avenue</b>			Telephone Number (Area Code)/Fax Number <b>(303) 988-1845 / 986-2898</b>			Lab Number		Page <b>1</b> of <b>2</b>	
City <b>GOLDEN</b>	State <b>CO</b>	Zip Code <b>80401</b>	Site Contact			Analysis			
Project Name <b>FRENCH GULCH</b>			Carrier/Waybill Number						

Contract/Purchase Order/Quote No.

**SUSAN MCCOOL**

Sample I.D. No. and Description	Date	Time	Sample Type	Total Volume	Containers		Preservative	Condition on Receipt	Total Zn, Cd, Fe										
					Type	No.													
FG0082 (FG-9) STREAM	5/24/97	1015	WATER	160L	POLY(VIN)	1	20% HNO <sub>3</sub>		X										
FG0084 (FG-7) STREAM	"	1045	"	"	"	"	"												
FG0085 (FG-8) STREAM	"	1115	"	"	"	"	"												
FG0086 (1121 seep)	"	1145	"	"	"	"	"												
FG0087 (USGS TS-4) stream	"	1200	"	"	"	"	"												
FG0088 (FG-60 seep)	"	1300	"	"	"	"	"												
FG0089 (FG-6C seep)	"	1315	"	"	"	"	"												
FG0090 (FC @ CB stream)	"	1345	"	"	"	"	"												
FG0091 (USGS FG-15 stream)	"	1400	"	"	"	"	"												
FG0092	"	1400	"	"	"	"	"												
FG0093 (KDS-5 SPRING)	"	1445	"	"	"	"	"												
FG0096 (FG-1 STREAM)	"	1530	"	"	"	"	"												
FG0097 (MW-12 GROUNDWATER)	5/30/97	940	"	"	"	"	"												
FG0098 (MW-14 GROUNDWATER)	"	1010	"	"	"	"	"												
FG0099 (MW-9 GROUNDWATER)	"	1035	"	"	"	"	"												
FG0100 (MW-11 GROUNDWATER)	"	1105	"	"	"	"	"												

Special Instructions

Possible Hazard Identification				Sample Disposal			
<input checked="" type="checkbox"/> Non-Hazard	<input type="checkbox"/> Flammable	<input type="checkbox"/> Skin Irritant	<input type="checkbox"/> Poison B	<input type="checkbox"/> Unknown	<input type="checkbox"/> Return To Client	<input checked="" type="checkbox"/> Disposal By Lab	<input type="checkbox"/> Archive For _____ Months
Turn Around Time Required				Project Specific (Specify)			
<input checked="" type="checkbox"/> Normal	<input type="checkbox"/> Rush	QC Level		see previous FRENCH GULCH REPORTS			
1. Relinquished By <b>Art Morrissey</b>		Date <b>5/31/97</b>	Time <b>10:45am</b>	1. Received By <b>Chant Wilson</b>		Date <b>5/31/97</b>	Time <b>1045</b>
2. Relinquished By		Date	Time	2. Received By		Date	Time
3. Relinquished By		Date	Time	3. Received By		Date	Time

Comments

# Chain of Custody Record



QUA-4124

Client <b>RAS, INC</b>			Project Manager <b>Art Morrissey</b>			Date <b>5/31/97</b>			Chain Of Custody Number <b>27210</b>		
Address <b>311 Rock Avenue</b>			Telephone Number (Area Code)/Fax Number <b>(303) 988-1845/986-2898</b>			Lab Number			Page <b>2</b> of <b>2</b>		
City <b>GOLDEN</b>	State <b>CO</b>	Zip Code <b>80401</b>	Site Contact			Analysis					
Project Name <b>FRENCH GULCH</b>			Carrier/Waybill Number								

Contract/Purchase Order/Quote No.

**SUSAN MCCOOL**

Sample I.D. No. and Description	Date	Time	Sample Type	Total Volume	Containers		Preservative	Condition on Receipt	Total Pb, Cu, Cd, Fe												
					Type	No.															
FG0101 (ORO SHAFT MINE WATER)	5/30/97	1120	WATER	1602	POLY(AM)	1	20% HNO <sub>3</sub>		X												
FG0102 (WRO-1 GROUNDWATER)	"	1240	"	"	"	"	"														
FG0103 (SBRE-3 GROUNDWATER)	"	1310	"	"	"	"	"														
FG0104 (MW-16 GROUNDWATER)	"	1325	"	"	"	"	"														
FG0105 (#3 PINE SHAFT MINE WATER)	"	1345	"	"	"	"	"														
FG0106 (seep)	"	1415	"	"	"	"	"														
FG0107 (MW-13 GROUNDWATER)	"	1430	"	"	"	"	"														
FG0108 (WTL-02 GROUNDWATER)	"	1510	"	"	"	"	"														
FG0109 (MW-2 GROUNDWATER)	"	1520	"	"	"	"	"														
FG0110 (MW-3 GROUNDWATER)	"	1550	"	"	"	"	"														

Special Instructions

Possible Hazard Identification

☒ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown

Turn Around Time Required

☒ Normal ☐ Rush

1. Relinquished By

*Art Morrissey*

2. Relinquished By

3. Relinquished By

QC Level

☐ I. ☐ II. ☐ III.

Date

**5/31/97**

Time

**10:45 AM**

Sample Disposal

☐ Return To Client ☐ Disposal By Lab ☐ Archive For \_\_\_\_\_ Months

Project Specific (Specify)

1. Received By

*Art Morrissey*

2. Received By

3. Received By

Date

**5/31/97**

Time

**1045**

Comments

DISTRIBUTION: WHITE - Stave with Sample; CANARY - Returned to Client with Report; PINK - Field Copy

Report No. IS-1007RAS3-10/97  
STATE FG97

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